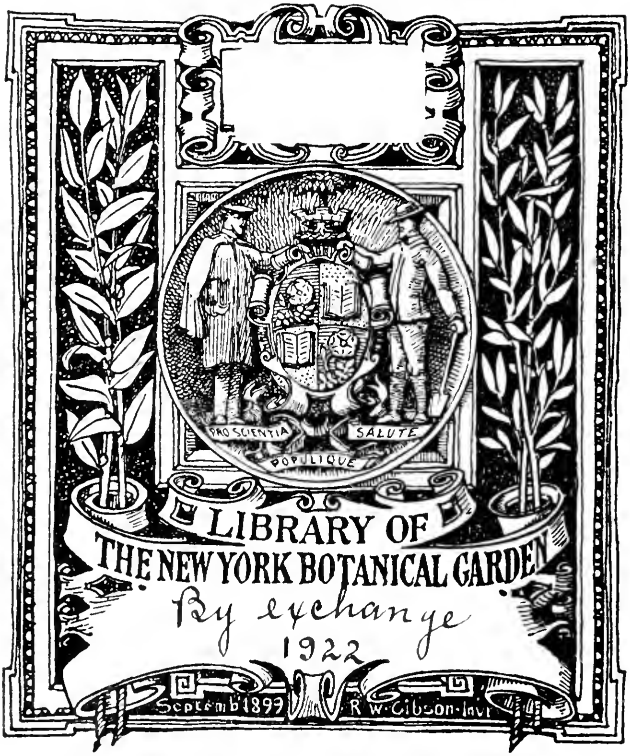
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SIXTIETH ANNUAL REPORT

OF THE

SECRETARY

OF THE

State Board of Agriculture

OF THE

STATE OF MICHIGAN

AND

THIRTY-FOURTH ANNUAL REPORT

OF THE

EXPERIMENT STATION

FROM

JULY 1, 1920, TO JUNE 30, 1921.

BY AUTHORITY

LANSING, MICHIGAN
WYNKOOP HALLENBECK CRAWFORD CO., STATE PRINTERS
1922

REPORT OF THE SECRETARY

OF THE

STATE BOARD OF AGRICULTURE

East Lansing, Mich., *July 1, 1921.*

To Hon. Alex. J. Groesbeck,

Governor of the State of Michigan:

Sir—I have the honor to submit to you herewith, as required by law, the accompanying report for the fiscal year ending June 30, 1921, with supplementary papers.

Very respectfully,

ADDISON M. BROWN,

Secretary of the State Board of Agriculture.

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	Term expires.
WILLIAM H. WALLACE, Saginaw	1st Monday January, 1922
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I. ROY WATERBURY, Detroit	1st Monday January, 1922
JOHN W. BEAUMONT, Detroit	1st Monday January, 1924
JASON WOODMAN, Paw Paw	1st Monday January, 1924
L. WHITNEY WATKINS, Manchester	1st Monday January, 1926
MRS. DORA STOCKMAN, Lansing	1st Monday January, 1926

THOMAS E. JOHNSON, SUPT. OF PUBLIC INSTRUCTION .... *Ex-Officio*
FRANK S. KEDZIE, PRESIDENT OF THE COLLEGE .... *Ex-Officio*
ADDISON M. BROWN, East Lansing, Secretary.
BENJAMIN F. DAVIS, Lansing, Treasurer.

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Ren G. Saxton, C. E., Assistant Professor of Civil Engineering.
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*Paul G. Andres, B. S., Assistant Professor of Electrical Engineering.
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Henry L. Publow, B. S., Assistant Professor of Chemistry.
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Ray B. Weaver, M. A., Assistant Professor of English.
*Grace S. Frear, B. S., Assistant Professor of Household Art.
Omar M. Lebel, Ph. B., Assistant Professor of English.
°Henrik J. Stafseth, B. S., D. V. M., Assistant Professor of Bacteriology.
I. Forest Huddleson, M. S., Assistant Professor of Bacteriology.
Osee Hughes, B. A., Assistant Professor of Household Science.
Edwin Morrison, M. S., Assistant Professor of Physics.
Wallace L. Chandler, Ph. D., Assistant Professor of Entomology.
Cecile Van Steenburg, B. S., Assistant Professor of Household Art.
Edmund C. Sauve, B. S., Assistant Professor of Farm Mechanics.
Vernon G. Grove, A. M., Assistant Professor of Mathematics.
Edward K. Sales, D. V. M., Assistant Professor of Surgery and Clinic.
Captain Joseph J. Teter, Assistant Professor of Military Science.
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Phillip L. Buttrick, Assistant Professor of Forestry.
Lawrence C. Wheeting, M. S., Assistant Professor of Soils.
Claude L. Brattin, B. M. E., Assistant Professor of Drawing and Design.
Paul R. Brees, A. B., Assistant Professor of Public Speaking.
Homer E. Dennison, B. S., Assistant Professor of Dairy Production.
Floyd E. Fogle, B. S. in Agr., Assistant Professor of Farm Mechanics.
Van W. Hewlett, Jr., B. S., Assistant Professor of Mechanical Engineering.
Caroline L. Holt, Assistant Professor of Drawing and Design.
Verne E. LeRoy, A. B., M. S., Assistant Professor of Zoology.
Walter L. Mallman, B. S., Assistant Professor of Bacteriology.
Carl E. Newlander, B. S., Assistant Professor of Dairy Manufactures.
Newton L. Partridge, Ph D., Assistant Professor of Horticulture.
May Person, A. B., Assistant Professor of Household Science.
Godfrey L. A. Ruehle, M. S., Assistant Professor of Bacteriology.
Frank A. Spragg, M. S., Assistant Professor of Farm Crops.
Earle H. Stewart, B. S. in M. E., Assistant Professor of Drawing and Design.
Thomas O. Walton, A. B., Assistant Professor of Mathematics.
George C. Wright, B. S. in M. E., Assistant Professor of Mechanical Engineering.
Frank E. Wood, Ph. D., Assistant Professor of Mathematics.

Branson A. Walpole, Assistant Professor of Education; Critic Teacher in Agriculture.

INSTRUCTORS AND OTHERS

The names of instructors whose resignations took effect between June 30th and September 1st, 1920, to not appear below.

Dewey A. Seeley, M. A., Instructor in Meteorology.
Bertha E. Thompson, M. A., Instructor in Botany.
Louis B. Mayne, A. B., Instructor in English.
Joseph W. Stack, M. S., Instructor in Zoology.
Charles D. Ball, Jr., B. S., Instructor in Chemistry.
Stanard G. Bergquist, A. B., Instructor in Zoology.
Harry C. Young, M. S., Instructor in Botany.
George J. Posthumus, Instructor in Pattern Shop.
Florence A. Stoll, B. S., Instructor in Household Art.
Benjamin F. Kindig, Instructor in Apiculture; State Bee Inspector.
Russell H. Kelty, B. S., Instructor in Entomology.
Myron B. Chapin, Ph. B., Instructor in Drawing and Design.
*Ruth M. Kellogg, B. S., Instructor in Household Science.
°J. Robert Duncan, Instructor in Farm Crops.
Howard D. Lightbody, M. S., Instructor in Chemistry.
Sergt. Charles H. Robinson, Instructor in Military Science and Tactics.
Herman C. Lange, A. B., Instructor in Chemistry.
Edward F. Eldridge, B. S., Instructor in Chemistry.
Edith Butler, Instructor in Drawing and Design.
Justus E. Rising, M. E., Instructor in Drawing and Design.
¶Andrew Watt, Instructor in Forge Shop.
Walter L. Watt, Instructor in Machine Shop Practice.
Carlyle W. Bennett, M. S., Instructor in Botany.
Cecil W. Simpson, B. S., Instructor in Soils.
Helen D. Grimes, Instructor in Physical Training.
Albert H. Nelson, A. M., Instructor in English
Levette J. Davidson, A. M., Instructor in English.
Lyman L. Frimodig, B. S., Instructor in Physical Training.
Minerva Fouts, Ph. B., Instructor in Household Art.
Daniel L. Shafer, Instructor in Farm Mechanics.
Ethel Taft, B. S., Instructor in Household Art.
Hilda M. Kellner, Instructor in Cheesemaking.
Oscar W. Fairbanks, B. S., Instructor in Drawing and Design.
David T. Millard, Instructor in Pattern Making.
Charles T. Bumer, B. S., Instructor in Mathematics.
Wilson E. Newlon, B. S., Instructor in Poultry Husbandry.
Arthur N. Smith, Instructor in Physical Training.
*Raymond L. Baxter, B. S., Instructor in Chemistry.
Eugene B. Butler, B. S., Instructor in Physics.
Charles E. Cormany, M. S. in Agr., Instructor in Farm Crops.
James Devers, Instructor in Physical Training.
Eugene E. Down, B. S., Instructor in Farm Crops.
George A. Garratt, B. S., Instructor in Forestry.
Louis G. Gentner, M. S., Instructor in Entomology.
Jay F. Gibbs, B. S., Instructor in Civil Engineering.
Fletcher A. Gould, B. S., Instructor in Civil Engineering.

Guy S. Green, A. B., Instructor in English.
John G. Heppinstall, Instructor in Physical Training.
Rufus P. Hibbard, Ph. D., Instructor in Botany.
Edward E. Kinney, B. S., Instructor in Electrical Engineering.
Harold M. Krebs, B. S., Instructor in Chemistry.
Denton C. Limbaugh, A. B., Instructor in English.
Jessie M. MacCornack, Instructor in Physical Training.
Clifford N. Rix, Instructor in Mechanical Engineering.
James E. Robertson, B. S., C. E., Instructor in Drawing and Design.
Avis L. Sprague, B. S., Instructor in Foods—Home Economics.
Wilbur H. Thies, B. S., Instructor in Physics.
John H. Walker, A. B., Instructor in Chemistry.
Bert Sangster, Instructor in Mechanical Engineering.
Ralph D. Wyckoff, B. S., Instructor in Electrical Engineering.
Wilford C. Lewis, M. S., Instructor in Chemistry.
Waldo H. Lyons, A. M., Instructor in Mathematics.
Stanley Johnston, B. S., Instructor in Horticulture.
George W. Putnam, Instructor in Farm Crops.
Linda E. Landon, Librarian.
Lory F. Newell, Operating Engineer.
Benjamin A. Faunce, Clerk to President.
Edwyn A. Bowd, College Architect.
Andrew P. Krentel, Foreman of the Pattern Shop.
Jacob Schepers, Cashier.
Ralph S. Hudson, B. S., Farm Foreman.
Maud A. Meech, Chief Clerk to Secretary.
Edward C. Crawford, Shop Engineer.
Elizabeth M. Palm, B. S., Assistant Librarian.
Blanche A. Birchard, Secretary to President.
Bertha A. Hollister, B. A., State Seed Analyst.
Jacob A. Eicher, Foreman of Foundry.
Anna L. Ferle, Assistant Registrar.
Jesse J. Hendryx, Nursery Foreman.
Nancy L. Eastman, In charge of College Residence.
Clara Hunt, Director Womens' Dormitories.
Robert Mackie, Herdsman.
Nellie M. Campbell, Bookkeeper.
Clifford W. McKibbin, M. S., M. F., Alumni Recorder.
Ashley M. Berridge, B. S., Director of Short Courses.
Sallie Katz, In charge of Waterbury House.
Mildred Osband, In charge of Senior House.
Frances Murdock, In charge of College Cottage.
Willard N. Sweeney, Purchasing Agent.
Caroline S. Lewerenz, In charge of Abbot Hall.
Emily P. Jones, In charge of Howard Terrace.
Clyde W. Straight, Farm Crops Foreman.
Ralph M. Harford, College Photographer.
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William Wise, Poultryman.
S. Elizabeth Morrison, B. S., Laboratory Assistant and Clerk.
Daniel A. Shafer, Laboratory Foreman.
May E. Foley, B. S., Assistant Alumni Recorder.

Elmer B. Hint, B. S., Superintendent of Official Testing.
Philip J. Baker, B. S., Metallurgical Engineer.
George Clark, Football and Baseball Coach.
Cora Feldcamp, B. S., Reference Librarian.
Josephine R. Hart, B. S., Critic Teacher in Home Economics.
James B. Hasselman, A. B., Publicity Agent.
Norman O. Weil, B. S., College Field Agent.
Earl A. Harlow, Storekeeper.
Hugh B. Smith, B. S., Grad. Assistant in Farm Crops.
Robert L. Tweed, B. S., Grad. Assistant in Bacteriology.
Lionel E. Tisdale, B. S., Grad. Assistant in Botany.
J. Lyall L. Frank, B. S., Grad. Assistant in Entomology.
Otto Friedman, B. S., Grad. Assistant in Bacteriology.
Wilfred D. Mills, B. S., Grad. Assistant in Botany.

EXPERIMENT STATION

Advisory and Assistant Staff

Andrew J. Patten, B. S., Chemist.
L. Zae Wyant, A. M., M. H. E., Research Associate in Bacteriology.
Charles S. Robinson, Ph. D., Research Associate in Chemistry.
Orrin B. Winter, B. A., Research Associate in Chemistry.
George J. Bouyoucos, Ph. D., Research Associate in Soils.
Leslie M. Cooledge, M. A., Research Associate in Bacteriology.
I. Forest Huddleson, M. S., Research Associate in Bacteriology.
George M. Grantham, B. S., (½ time. Balance Extension), Research Associate in Soils.
Ezra Levin, M. S., (½ time. Balance Extension), Research Associate in Soils.
Charles H. Spurway, B. S. in Agr., Research Associate in Soils.
Raymond Nelson, B. S., Research Assistant in Plant Pathology.
Robert M. Snyder, Ph. D., Research Assistant in Bacteriology.
John E. Kotila, B. S., Research Assistant in Plant Physiology.
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William J. Kurtz, B. S., Assistant in Dairying.
Arthur Howland, Assistant in Dairying.
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Ezra A. Hebard, Inspector of Feeds and Fertilizers.
August H. Teske, Inspector of Feeds and Fertilizers.
H. Donald Hootman, B. S., Superintendent of Graham Horticultural Experiment Station.
D. L. McMillan, Superintendent of Upper Peninsula Experiment Station.
Myra V. Bogue, Bulletin Clerk.

*Resigned.
°Absent on leave.
¶Deceased March 14, 1921.

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(Under the control of the State Board of Agriculture.)

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Elam T. Hallman, D. V. M., Animal Pathologist.
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Charles H. Burgess, A. B., Poultry Husbandman.
Addison M. Brown, B. A., Secretary.

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Karl H. McDonel, B. S. . . . . Assistant to Director.

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Duane F. Rainey, B. S. . . . . Farm Crops.

*Clarence William Waid, B. S. . . . . Potatoes and Vegetables.
Henry C. Moore, B. S. Ass't Potatoes and Vegetables.
Russel M. Hain, B. S. . . . . Insect Pests.
Edwin Ewell . . . . Apiculture.
Orsel Edwin Robey, B. S. . . . . Drainage.
George M. Grantham, B. S. . . . . Soils.
Ezra Levin, M. S. . . . . Soils.
°Ernest C. Foreman, B. S. . . . . Poultry Husbandry
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Gifford Patch, B. S. . . . . Ass't in Marketing.
Willard C. Cribbs . . . . Ass't in Marketing.
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Edna Viola Smith, B. S. . . . . Home Management.
*Coral Ruth Havens . . . . Household Science.
Helen Arms, B. S. . . . . Household Art.

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Frank W. Bennett . . . . Barry.
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Sidney Samuel Smith, B. S. . . . . Genesee.
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Carl Edwin Gunderson, B. S. . . . . Gogebic.
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Ralph Leslie Olds, B. S. . . . . Kalamazoo.
Ellis Eugene Twing . . . . Kalkaska.
Roswell Gilbert Carr, B. S. . . . . Kent.
Stanley Fredrick Wellman, B. S. . . . . Lapeer.
Victor Carlton Vaughan, B. S. . . . . Leelanau.
Ralph J. Carr, B. S. . . . . Lenawee.
Fred S. Dunks, B. S. . . . . Livingston.
Roy Harry Cameron, B. S. . . . . Luce.
Kris Paul Bemis, B. S. . . . . Mason.

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William Murphy, B. S	Macomb.
Lee Roy Walker, B. S	Marquette.
B. Eldon Shaffer, B. S	Montcalm.
Irving Kirshman, B. S	Menominee.
Mack Cyrus Thomas	Monroe.
Ira Benona McMurtry	Midland.
Paul H. Smith, B. S	Missaukee.
Murray F. Jackson	Mecosta.
Dwight Clark Long, B. S	Muskegon.
Clair Taylor	Newaygo.
Irving T. Pickford, B. S., M. Hort	Oceana.
William Edward McCarthy, B. S	Ogemaw.
Charles Benjamin Cook, B. S	Oakland.
Arthur Clinton Lytle, B. S	Otsego.
Clinton Pomeroy Milham, B. S	Ottawa.
Edward Samuel Brewer	Presque Isle.
Arthur Grant Bovay, B. S	Saginaw.
John D. Martin, B. S	Sanilac.
Cecil Perth Pressley, B. S	Schoolcraft.
Carl May Kidman, B. S	St. Clair
J. Vernon Sheap	Shiawassee.
Alem John Hutchins, B. S	St. Joseph.
Alexander MacVittie, B. S	Tuscola.
Wesley Clare Eckard	Van Buren.
Orestes Isiah Gregg, B. S	Wayne.
William Frederick Johnston, B. S	Wexford.
Harold Scott Osler, B. S	Washtenaw.

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Bernice Jennie Woodworth, B. S	Allegan.
Helen Columbia Pratt, B. S	Chippewa.
Sylvia Richardson	Delta.
Helen Edith Simonson	Dickinson.
Flora Emma McElhinney	Houghton.
Blanche Clark	Kalamazoo.
Eva Carrett, B. S	Oakland.
Grace Pinnell, B. S	Manistee.
Marion H. Rogers, B. S	Wayne.

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William A. Anderson, B. S	Ass't State Club Leader.
Barbara Van Heulen, B. S	Ass't State Club Leader.
Elda Iantha Robb, B. S	Ass't State Club Leader.
*Margaret Hutty	Ass't State Club Leader.
Arne Gerald Kettunen, B. S	Ass't State Club Leader.

COUNTY CLUB LEADERS

Viva Lorene Osborn	Branch.
Charles Ernest Ackley	Calhoun.
Ann Rosale Banks	Cheboygan.
Ralph Whitcomb Tenny, B. S.	Eaton.
Kelsey Bostock Smith	Genesee.
Levi Pfenning	Gladwin.
Mary V. Hall	Iron.
Majorie E. Place	Lenawee.
Harold Canfield, B. S.	Macomb.
Arthur Lawrence Strang, B. S.	Saginaw.
Beryl Otto Hagerman, B. S.	Washtenaw.
Glen Orlando Stewart, B. S.	Wayne.

* Resigned.
° Absent on leave.

ACCOUNT OF THE

THE MICHIGAN AGRICULTURAL COLLEGE

FOR THE YEAR ENDING JUNE 30, 1922.

SECRETARY'S FINANCIAL REPORT.

July 1, 1920.	Cash on hand		$11,039 63	
July 1, 1920.	Cash on Deposit College Treasurer		52,993 35	
June 30, 1921.	To Special appropriation receipts		518,693 48	
	From State Treasurer	$296,938 27		
	From United States Treasurer	178,172 80		
	From Institution and other Sources	43,582 41		
June 30, 1921.	By Disbursements			$560,077 53
	Special Appropriations	52,893 00		
	Experiment Station	266,039 39		
	Extension	241,145 14		
June 30, 1921.	To current account receipts		1,307,556 60	
	From State Treas., land grant int.	70,685 37		
	Fron State Treas., one-fifth mill tax.	797,986 71		
	(a) $935,000 00			
	(b) 150,000 00			
	(c) 287,013 29			
	From United States Treasurer, Morrill Fund	50,000 00		
	From institution and other Sources	388,884 52		
	By general account disbursements			1,339,873 84
June 30, 1921.	By cash on hand			12,199 86
June 30, 1921.	By cash on deposit overdrawn		21,868 17	
			$1,912,151 23	$1,912,151 23

(a) Mill tax.
(b) Unexpended July 1, 1920.
(c) Appropriation for extension, $90,000.00.
(c) Appropriation for Experiment Station, $197,013.29.

TABLE No. 1.—*Tabular Exhibit of Secretary's reports.*

	Balance sheet July 1, 1920.		Transactions July 1, 1920 to June 30, 1921.		Balance sheet June 30, 1921.	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
Cash	$11,039 63			$1,160 23	$12,199 86	
(a) College treasurer	52,993 35		$74,861 52			$21,868 17
Special appropriations		11,702 10	12,288 58	52,893 00		
Current accounts		52,330 88	1,307,556 60	1,339,873 84	28,902 32	
Experiment station			266,039 39	266,039 39		20,013 64
Extension			240,365 51	241,145 14	779 63	
Total	$64,032 98	$64,032 98	$1,901,111 60	$1,901,111 60	$41,881 81	$41,881 81

(a) Treasurer's statement is greater July 1, 1920 by $65,553.24 and June 30, 1921 by $23,443.36. Warrants outstanding.

TREASURER'S ACCOUNT.

	Dr.	Cr.
Balance on hand July 1, 1920	$111,773 90	
Receipts from State treasurer and secretary of the college	1,813,929 48	
Interest on deposits during the year	1,160 91	
Warrants paid July 1, 1920 to June 30, 1921		$1,925,289 10
Balance on hand June 30, 1921		1,575 19
Total	$1,926,864 29	$1,926,864 29

TABLE No. 2.—*Statement of special appropriation accounts for the fiscal year ending June 30, 1921.*

	Balance of accounts July 1, 1920.		Receipts.		Total available.	Total expended.	Balance of accounts June 30, 1921.	
	Dr.	Cr.	From State Treasurer.	From Institution and other sources.			Dr.	Cr.
Experiment station	....	....	(a)$227,013 29	$39,026 10	$266,039 39	$266,039 39	....	....
Extension	....	....	(b) 238,172 80	2,192 71	240,365 51	241,145 14	$779 63	....
Geo. L. Allen Scholarship	....	$86 38	....	75 00	161 38	....	....	$161 38
Lawson memorial prize	$12 50	....	....	25 00	12 50	25 00	12 50	....
Marilla Griswold scholarship	....	96 17	....	110 00	206 17	....	....	206 17
Nursery license	....	....	....	1,928 50	1,928 50	1,928 50	....	....
Sayer fund	....	12 20	....	37 50	49 70	25 00	....	24 70
U. S. army school	....	12,648 83	....	186 50	12,835 33	12,835 33	....	....
Vocational teacher training	254 30	....	9,924 98	....	9,670 68	13,948 22	4,277 54	....
Weather service	....	213 68	....	....	213 68	....	....	213 68
Totals	$266 80	$13,057 26	$175,111 07	$43,581 31	$531,482 84	$535,946 58	$5,069 67	$605 93
Shops and storehouse	1,088 36	....	....	1 10	1,087 26	24,130 95	25,218 21	....
Totals	$1,355 16	$13,057 26	$475,111 07	$43,582 41	$532,570 10	$560,077 53	$30,287 88	$605 93

(a) $30,000.00 United States treasurer.
(b) $148,172.80 United States treasurer.

TABLE No. 3.—*William Smith Sayer Scholarship Fund.*

	Year ending June 30.	Income.	Income expended to	Amount.	Balance including principal.
$500.00 received of F. F. Sayer, administrator of the estate of William Smith Sayer, to establish scholarship in bacteriology........	1910	$32 25	A. McVittie........	$19 75	$512 20
	1911	37 50	....	....	550 00
	1912	12 50	D. K. Fisher......	25 00	515 50
			H. D. Wright.....	25 00	
	1913	25 00	D. Francisco........	25 00	515 35
	1914	24 85	R. W. Waffle........	25 00	512 20
	1915	24 85	J. D. Baker........	25 00	512 20
	1916	25 00	J. M. Maze........	25 00	512 20
	1917	25 00	Elsa Scheuren......	25 00	512 20
	1918	25 00	....	....	537 20
	1919	25 00	Elwyn Younker...	25 00	512 20
			Ethel Hopphan.,..	25 00	
	1920	25 00	Esther Severance...	25 00	512 20
	1921	37 50	Thelma Forter......	25 00	524 70
Total........................	....	$319 45	....	$294 75	

TABLE No. 4.—*Geo. E. Lowson Memorial Prize.*

FUND.	Year ending June 30.	Income.	Income expended to	Amount.	Balance including principal.
$500.00 received of John W. Beaumont, in memory of Geo. E. Lawson to offer annual cash prize for the best essay in English produced by male student.................	1917	$25 00	I. B. McMurtry....	$25 00	$500 00
	1918	12 50	H. C. Diehl.........	25 00	487 50
	1919	25 00	Stanley Powell......	25 00	487 50
	1920	25 00	Fred F. Henshaw...	25 00	487 50
	1921	25 00	Herman E. Segelin,.	25 00	512 50
Total........................	....	$112 50	....	$125 00	

TABLE No. 5.—*Geo. L. Allen Scholarship.*

	Year ending June 30.	Income.	Income expended to	Amount.	Balance including principal.
$1,000.00 received of Amanda A. Ransom to be used in assisting the poor and deserving young men in obtaining their education.........	1919	....	....	....	$1,036 38
	1920	$50 00	....	....	1,086 38
	1921	75 00	....	....	1,161 38
Total........................		$125 00			

TABLE No. 6.—*Marilla Griswold Scholarship.*

	Year ending June 30.	Income.	Income expended to	Amount.	Balance including principal.
$2,000.C0 received of Orion S. Cross, executor of the estate of Marilla Griswold, the income of the same to be used under the direction of the State Board of Agriculture to help needy students. Preference being given to those from Allegan County.	1920	$110 00	....	$13 83	$2,096 17
	1921	110 00	....	....	2,206 17
Total....................	....	$220 00	....	$13 83	

TABLE No. 7.—*Current Account July 1, 1920 to June 30, 1921.*

	Dr. To disbursements.	Cr. By receipts.
U. S. Treasurer 31st annual payment under act of congress of August, 1890	....	$50,000 00
State Treasurer, one-fifth mill fund	....	797,986 71
State Treasurer, interest on proceeds of sale of U. S. land grant	....	70,685 37
Agricultural Education	$655 92	
Anatomy	3,417 98	330 17
Animal Husbandry	28,733 80	9,951 44
Bacteriology	23,873 72	6,640 08
Botany	30,920 12	1,534 24
Chemistry	59,862 96	12,231 83
Civil Engineering	23,251 00	535 00
Dairy husbandry	120,672 00	102,068 72
Drawing	38,582 30	2,752 00
Economics	8,968 83	17 00
Electrical engineering	17,570 98	410 52
English	32,491 33	275 38
Entomology	13,161 60	204 62
Farm crops	19,274 49	203 84
Farm and horses	49,285 86	27,394 13
Farm mechanics	18,042 41	3,101 15
Farm management	3,658 97	....
Forestry	17,550 66	3,581 97
History	8,545 61	127 40
Horticulture	20,763 69	2,481 49
Household art	19,885 40	2,160 40
Household science	23,533 26	5,097 10
Library	10,475 07	43 49
Mathematics	24,907 93	363 37
Mechanical engineering	46,367 60	4,626 01
Meteorology	600 30	12 00
Military science	7,067 69	393 19
Music	7,135 40	2,241 25
Pathology	5,083 84	19 01
Physics	24,093 50	2,870 48
Physical training	32,233 11	4,031 60
Poultry	17,897 60	3,411 20
Soils	12,709 68	235 43
Special courses	16,496 77	3,087 95
Surgery and clinic	11,582 83	852 73
Veterinary science	9,461 49	134 24
Zoology	19,882 04	718 75
Advertising	7,523 03	1 00
Alumni recorder	9,247 41	24
Cleaning	21,465 99	2,531 16
Commencement	368 36	....
Convocations	696 02	....
Dean of agriculture	4,844 98	....
Dean of engineering	8,237 73	....
Dean of summer school	14,575 39	....
Dean of women	26,643 54	2,440 11
Dean of home economics	3,505 50	....
Diplomas	792 11	1,080 00
Electric lighting	16,112 26	2,919 23
Expense board members	892 80	....
Federal students	14,934 10	18,833 33
Freight and cartage	4,246 93	124 37
General	12,404 27	16,237 68
Heating	129,303 76	1,597 91
Health service	13,724 32	6,830 34
Land improvement	238 29	18 00
Maintenance and repair of buildings	72,425 23	(a)122,398 24

TABLE No. 7.—*Current Account July 1, 1920 to June 30, 1921.*—Concluded.

	Dr. To disbursements.	Cr. By receipts.
Maintenance of grounds	$10,993 96	$18 86
New buildings and additions	71,340 53	53 78
Office of president	16,410 52	1,448 15
Office of secretary	32,402 04	6,709 15
Registrar	8,829 53	....
Hospitals	1,068 26	2 14
Telephone	3,127 06	187 94
Store	4,828 27	1,313 71
Total	$1,339,873 84	$1,307,556 60
Balance beginning fiscal year July 1, 1920	....	52,330 88
Balance on hand June 30, 1921	20,013 64	....
Total	$1,359,887 48	$1,359,887 48

(a) Supplies, $9,237.75; sundry, $530.11; labor, $13,553.68; rental, $1,407.48; tuition, $5,667.50; incidental, $60,597.20; matriculation ,$3,503.00; delinquent, $572.00; room rent, $27,324.53; diploma, $5.00.

TABLE NO. 7.—*Distribution of Special Appropriations.*

	Dr. To disbursements.	Cr. By receipts.
Nursery license and inspection	$1,928 50	$1,928 50
Sayer fund	25 00	37 50
G. E. Lawson Memorial Fund	25 00	25 00
Geo. L. Allen scholarship	....	75 00
Vocational teacher training	13,948 22	9,924 98
United States army school	12,835 33	186 50
Shops and storehouse	24,130 95	1 10
Marilla Griswold scholarship	....	110 00
Total	$52,893 00	$12,288 58
Balance beginning fiscal year July 1, 1920	....	$11,702 10
Balance overdrawn June 30, 1921	....	28,902 32
Total	$52,893 00	$52,893 00

TABLE No. 8.—*Experiment Station Account for Fiscal Year Ending June 30, 1921.*

	Disbursements.			Dr. total disbursements each department.	Cr. by receipts.
	Adams.	Hatch.	State.		
Balance on hand July 1, 1920					00
United States treasurer					$30,000 00
State Treasurer, one-fifth mill fund					197,013 29
Fertilizer feeds			$1,547 24	$1,547 24	8,940 00
Commercial feeding stuffs			1,153 08	1,153 08	16,480 00
Animal husbandry			2,882 14	2,882 14	1,071 02
Bacteriology			10,192 51	10,192 51	540 17
Botany			4,991 18	4,991 18	125 55
Chemistry			4,605 76	4,605 76	102 77
Dairy husbandry			2,229 63	2,229 63	
Director's office			22,435 44	22,435 44	27 72
Entomology			1,699 65	1,699 65	141 00
Farm crops			12,083 91	12,083 91	3,909 04
Forestry			57 06	57 06	
Farm management			155 60	155 60	
Farm mechanics			617 65	617 65	
Horticulture			4,264 20	4,264 20	29 60
Library			444 60	444 60	
Poultry			32 25	32 25	
Salaries	$15,000 00	$15,000 00	93,500 66	123,500 66	
Soils			14,874 61	14,874 61	22 00
Graham horticultural station			29,676 57	29,676 57	458 70
South Haven station			3,608 48	3,608 48	685 62
U. P. station			24,987 17	24,987 17	6,492 91
Balance, June 30, 1921					00 00
Total	$15,000 00	$15,000 00	$236,039 39	$266,039 39	$266,039 39

TABLE No. 9.—*Extension Account for Fiscal Year Ending June 30, 1921.*

	Disbursements.			Dr. total disbursements each department.	Cr. by Receipts.
	Lever.	Lever State.	State.		
Balance July 1, 1920					$0 00
U. S. Treasurer Lever fund					148,172 80
State Treasurer, one-fifth mill extension lever state					90,000 00
Administration	$2,735 36	$13,370 56	$125 04	$16,230 96	309 80
Boys' and girls' club	17,781 96	13,444 95	945 28	32,172 19	158 26
Control insect pests	2,198 46	3,542 48	21 01	5,761 95	
County agents	75,439 72	5,390 09	369 95	81,199 76	101 10
Fairs			3,695 44	3,695 44	1 00
Farm crops	7,049 94	6,926 35	212 92	14,189 21	4 90
Farm management	2,937 65	1,221 53	82 15	4,241 33	1,389 70
Home demonstration agents	9,317 89	5,576 60	47 26	14,941 75	91 70
Home economics	7,501 34	9,954 05	48 20	17,503 59	22 10
Horticulture	2,227 10	1,750 34	24 47	4,001 91	32 50
Household engineer	1,574 72	2,749 68	234 16	4,558 56	
Live stock	3,023 73	4,267 21	194 07	7,485 01	59 00
Markets	5,692 42	8,407 82	291 59	14,391 83	
Muck crops			312 14	312 14	
Potatoes and vegetables	2,651 74	4,731 89	12 69	7,396 32	12 50
Poultry	972 06	1,630 90	25 55	2,628 51	
Publications	3,178 31	112 69	164 50	3,455 50	10 15
Soils	3,890 40	2,667 52	421 26	6,979 18	
Balance, overdrawn June 30, 1921					779 63
Total	$148,172 80	$85,744 66	$7,227 68	$241,145 14	$241,145 14

TABLE No. 10.—*Positions and salaries as shown by pay-roll dated June 30, 1921.*

	Rate per year.	Classification.		Extension.
		Current.	Experiment Station.	
Administration and miscellaneous:				
President's office:				
President	$8,000 00	$8,000 00	....	....
Clerk to president	3,000 00	3,000 00	....	....
Secretary to president	1,700 00	1,700 00	....	....
Secretary's office:				
Secretary	5,500 00	(a)5,000 00	$500 00	....
Cashier and assistant secretary	3,600 00	3,100 00	500 00	....
Bookkeeper	1,700 00	1,300 00	400 00	....
Chief clerk	2,600 00	850 00	....	$1,750 00
Clerk	1,700 00	1,700 00	....	....
Clerk	1,400 00	1,400 00	....	....
Clerk	1,400 00	1,400 00	....	....
Clerk	1,400 00	1,400 00	....	....
Clerk	1,300 00	1,300 00	....	....
Purchasing agent	2,800 00	2,800 00	....	....
Storekeeper	1,800 00	1,800 00	....	....
Registrar's office:				
Registrar	3,000 00	3,000 00	....	....
Assistant registrar	2,000 00	2,000 00	....	....
Clerk	1,600 00	1,600 00	....	....
Library:				
Librarian	2,800 00	2,400 00	400 00	....
Assistant librarian	1,800 00	1,800 00	....	....
Reference librarian	1,800 00	1,800 00	....	....
Alumni office:				
Alumni recorder	4,100 00	4,100 00	....	....
Assistant alumni recorder	1,600 00	1,600 00	....	....
Miscellaneous:				
Engineer	2,800 00	2,800 00	....	....
Night watchman	1,300 00	1,300 00	....	....
Architect	3,500 00	3,500 00	....	....
Y. M. C. A. secretary	500 00	500 00	....	....
Health service:				
Director	3,300 00	3,300 00	....	....
Dispensary clerk and secretary	1,600 00	1,600 00	....	....
Division of home economics:				
Dean	4,500 00	4,500 00	....	....
Stenographer	1,500 00	(b)1,500 00	....	....
Dean of women:				
Dean	3,600 00	(b)3,600 00	....	....
Director	2,700 00	(b)2,700 00	....	....
Matron senior house	1,200 00	(b)1,200 00	....	....
Matron college residence	1,350 00	(b)1,350 00	....	....
Matron Abbot Hall	1,000 00	(b)1,000 00	....	....
Matron Howard Terrace	1,000 00	(b)1,000 00	....	....
Matron College Cottage	850 00	(b) 850 00	....	....
Matron Waterbury House	850 00	(b) 850 00	....	....
Secretary	1,500 00	(b)1,500 00	....	....
Household Art:				
Professor	3,500 00	3,500 00	....	....
Associate Professor	3,200 00	3,200 00	....	....
Assistant Professor	3,000 00	3,000 00	....	....
Instructor	2,400 00	2,400 00	....	....
Instructor	1,800 00	1,800 00	....	....
Instructor	1,800 00	1,800 00	....	....

TABLE No. 10.—Continued.

	Rate per year.	Classification.		Extension.
		Current.	Experiment Station.	
Household science:				
Professor	$4,000 00	$4,000 00	....	....
Assistant professor	3,100 00	3,100 00	....	....
Assistant professor	3,000 00	3,000 00	....	....
Assistant professor	3,000 00	3,000 00	....	....
Instructor	2,400 00	2,400 00	....	....
Farm management:				
Professor	4,250 00	4,250 00	....	....
Assistant	1,500 00	1,500 00	....	....
Assistant	1,500 00	1,500 00	....	....
Division of engineering:				
Deans office:				
Dean	5,500 00	(a)5,500 00	....	....
Clerk and secretary	1,500 00	1,500 00	....	....
Drawing and design:				
Professor	5,000 00	5,000 00	....	....
Associate professor	3,600 00	3,600 00	....	....
Associate professor	3,200 00	3,200 00	....	....
Associate professor	3,200 00	3,200 00	....	....
Assistant professor	2,600 00	2,600 00	....	....
Assistant professor	2,600 00	2,600 00	....	....
Assistant professor	2,500 00	2,500 00	....	....
Assistant professor	2,400 00	2,400 00	....	....
Instructor	2,200 00	2,200 00	....	....
Instructor	2,200 00	2,200 00	....	....
Instructor	2,200 00	2,200 00	....	....
Instructor	1,800 00	1,800 00	....	....
Instructor	2,200 00	2,200 00	....	....
Stenographer	1,300 00	1,300 00	....	....
Civil engineering:				
Professor	4,000 00	(a)4,000 00	....	....
Associate professor	3,200 00	3,200 00	....	....
Assistant professor	2,800 00	2,800 00	....	....
Assistant professor	2,500 00	2,500 00	....	....
Assistant professor	2,600 00	2,600 00	....	....
Assistant professor	2,800 00	2,800 00	....	....
Instructor	2,000 00	2,000 00	....	....
Instructor	2,000 00	2,000 00	....	....
Mechanical engineering:				
Professor	4,250 00	4,250 00	....	....
Assistant professor	2,800 00	2,800 00	....	....
Assistant professor	2,600 00	2,600 00	....	....
Assistant professor	2,600 00	2,600 00	....	....
Instructor	2,200 00	2,200 00	....	....
Instructor	2,200 00	2,200 00	....	....
Instructor	1,800 00	1,800 00	....	....
Instructor	2,000 00	2,000 00	....	....
Instructor	2,000 00	2,000 00	....	....
Instructor	1,900 00	1,900 00	....	....
Instructor	2,400 00	2,400 00	....	....
Metallurgical engineer	2,600 00	2,600 00	....	....
Shop engineer	1,500 00	1,500 00	....	....
Electrical engineering:				
Professor	4,500 00	4,500 00	....	....
Associate professor	3,200 00	3,200 00	....	....
Associate professor	3,200 00	3,200 00	....	....
Instructor	2,000 00	2,000 00	....	....
Instructor	2,400 00	2,400 00	....	....
Federal students:				
Director	3,000 00	3,000 00	....	....
Instructor	1,800 00	1,800 00	....	....
Instructor	1,620 00	1,620 00	....	....
Instructor	1,200 00	1,200 00	....	....

TABLE No. 10.—Continued.

	Rate per year.	Classification. Current.	Classification. Experiment Station.	Extension.
Divisions of science and letters:				
Bacteriology:				
Professor	$4,750 00	$3,150 00	$1,600 00	
Associate professor	3,200 00	2,400 00	800 00	
Associate professor	3,400 00	1,200 00	2,200 00	
Associate professor	3,200 00	1,000 00	2,200 00	
Assistant professor	2,400 00	2,400 00		
Assistant professor	2,400 00	800 00	1,600 00	
Graduate assistant	800 00	800 00		
Research associate in bacteriology	3,200 00		3,200 00	
Research associate in bacteriology	3,600 00		3,600 00	
Research assistant in bacteriology	2,600 00		2,600 00	
Stenographer	1,300 00	1,300 00		
Department of botany:				
Professor	4,500 00	(a)3,600 00	900 00	
Associate professor	3,500 00	3,500 00		
Associate professor	3,800 00	1,900 00	1,900 00	
Associate professor	3,400 00	1,350 00	2,050 00	
Assistant professor	3,000 00	3,000 00		
Assistant professor	2,800 00	2,800 00		
Instructor	2,800 00	700 00	2,100 00	
Instructor	2,400 00	2,400 00		
Instructor	2,400 00	2,400 00		
Graduate assistant	800 00	800 00		
Graduate assistant	800 00	800 00		
Seed analyst	800 00	800 00		
Research assistant in botany	2,400 00		2,400 00	
Research assistant in plant physiology	2,600 00		2,600 00	
Stenographer	1,350 00	900 00	450 00	
Department of Chemistry:				
Professor	5,000 00	5,000 00		
Associate professor	3,800 00	3,800 00		
Associate professor	3,800 00	3,800 00		
Associate professor	3,200 00	3,200 00		
Assistant professor	2,600 00	2,600 00		
Assistant professor	3,000 00	3,000 00		
Assistant professor	2,800 00	2,800 00		
Instructor	2,400 00	2,400 00		
Instructor	2,200 00	2,200 00		
Instructor	2,300 00	2,300 00		
Instructor	2,400 00	2,400 00		
Instructor	2,200 00	2,200 00		
Instructor	1,800 00	1,800 00		
Instructor	1,800 00	1,800 00		
Dispensing clerk	1,800 00	1,800 00		
Department of English:				
Professor	4,000 00	(a)4,000 00		
Associate professor	3,400 00	3,400 00		
Assistant professor	2,800 00	2,800 00		
Assistant professor	2,600 00	2,600 00		
Assistant professor	2,600 00	2,600 00		
Assistant professor	2,600 00	2,600 00		
Assistant professor	2,600 00	2,600 00		
Instructor	2,000 00	2,000 00		
Instructor	1,800 00	1,800 00		
Instructor	3,200 00	1,000 00		$2,200 00
Instructor	2,300 00	2,300 00		
Instructor	2,000 00	2,000 00		
Instructor	1,800 00	1,800 00		
Department of economics:				
Professor	4,500 00	4,500 00		
Associate professor	3,500 00	3,500 00		
Stenographer	1,300 00	600 00		700 00

TABLE No. 10.—Continued.

	Rate per year.	Classification. Current.	Classification. Experiment Station.	Extension.
Department of Mathematics:				
Professor	$5,000 00	$5,000 00		
Associate professor	3,800 00	3,800 00		
Assistant professor	2,800 00	2,800 00		
Assistant professor	3,000 00	3,000 00		
Assistant professor	2,400 00	2,400 00		
Assistant professor	2,600 00	2,600 00		
Assistant professor	2,600 00	2,600 00		
Instructor	2,100 00	2,100 00		
Instructor	2,000 00	2,000 00		
Department of Meteorology:				
Instructor	600 00	600 00		
Department of military science:				
Professor	2,450 00	2,450 00		
Instructor	1,170 00	1,170 00		
Chief clerk	500 00	500 00		
Department of music:				
Director	3,500 00	3,500 00		
Department of physics:				
Professor	4,500 00	4,500 00		
Associate professor	3,200 00	3,200 00		
Assistant professor	2,700 00	2,700 00		
Instructor	2,300 00	2,300 00		
Instructor	2,200 00	2,200 00		
Clerk and assistant	1,200 00	1,200 00		
Photographer	1,900 00	1,900 00		
Caretaker	1,300 00	1,300 00		
Department of physical training:				
Director	6,000 00	6,000 00		
Instructor	2,800 00	2,800 00		
Instructor	2,200 00	2,200 00		
Instructor	2,500 00	2,500 00		
Instructor	2,000 00	2,000 00		
Instructor	1,700 00	1,700 00		
Coach	2,000 00	2,000 00		
Department of Zoology:				
Professor	4,250 00	(a)4,250 00		
Associate professor	3,200 00	3,200 00		
Associate professor	3,200 00	3,200 00		
Assistant professor	2,500 00	2,500 00		
Instructor	2,400 00	2,400 00		
Instructor	2,400 00	2,400 00		
Stenographer	650 00	650 00		
Division of veterinary medicine:				
Veterinary department:				
Acting dean	4,200 00	4,200 00		
Assistant professor	3,000 00	3,000 00		
Stenographer	650 00	650 00		
Department of anatomy:				
Assistant professor	2,800 00	2,800 00		
Department of pathology:				
Associate professor	4,000 00	2,000 00	$2,000 00	
Assistant professor	2,600 00	2,600 00		
Department of surgery and clinic:				
Associate professor	3,800 00	3,800 00		
Assistant professor	2,600 00	2,600 00		
Division of agriculture:				
Deans office:				
Dean	5,500 00	(a)2,750 00	2,750 00	
Assistant to dean	3,000 00	1,500 00	1,500 00	
Clerk	1,600 00	800 00	800 00	

TABLE No. 10.—Continued.

	Rate per year.	Classification. Current.	Experiment Station.	Extension.
Department of farm mechanics:				
Professor	$4,500 00	$3,600 00	$900 00	....
Assistant professor	2,600 00	1,300 00	1,300 00	....
Assistant professor	2,400 00	1,200 00	1,200 00	....
Instructor	1,800 00	1,800 00	....	....
Stenographer	675 00	675 00	....	....
Department of poultry:				
Professor	4,250 00	3,400 00	850 00	....
Instructor	2,000 00	1,300 00	700 00	....
Foreman	1,600 00	1,600 00	....	....
Department of forestry:				
Professor	5,000 00	4,000 00	1,000 00	....
Assistant professor	2,600 00	2,600 00	....	....
Instructor	2,000 00	2,000 00	....	....
Foreman nursery	1,900 00	1,900 00	....	....
Stenographer	1,300 00	1,300 00	....	....
Department of horticulture:				
Professor	4,500 00	3,000 00	1,500 00	....
Associate professor	3,500 00	3,500 00	....	....
Assistant professor	2,400 00	2,400 00	....	....
Assistant professor	2,750 00	1,375 00	1,375 00	....
Assistant professor	2,600 00	2,100 00	500 00	....
Research associate in horticulture	2,800 00	....	2,800 00	....
Research assistant in horticulture	3,500 00	....	900 00	$2,600 00
Instructor	300 00	300 00	....	....
Clerk	1,350 00	675 00	675 00	....
Department of animal husbandry:				
Professor	4,250 00	2,850 00	1,400 00	....
Assistant professor	2,800 00	2,100 00	700 00	....
Foreman	1,800 00	1,800 00	....	....
Stenographer	675 00	675 00	....	....
Department of dairy husbandry:				
Professor	5,500 00	5,500 00	....	....
Associate professor	3,200 00	3,200 00	....	....
Associate professor	3,000 00	3,000 00	....	....
Assistant professor	3,000 00	3,000 00	....	....
Assistant professor	3,000 00	2,000 00	1,000 00	....
Instructor	1,800 00	1,800 00	....	....
Research assistant in dairying	2,800 00	....	2,800 00	....
Research assistant in dairying	2,400 00	....	2,400 00	....
Accountant in dairy investigation	1,500 00	....	1,500 00	....
Accountant in dairy investigation	1,700 00	....	1,700 00	....
Superintendent advanced registry	1,800 00	1,800 00	....	....
Clerk	1,350 00	675 00	675 00	....
Clerk	1,250 00	1,250 00	....	....
Department of farm crops:				
Professor	4,500 00	3,000 00	1,500 00	....
Assistant professor	4,000 00	1,000 00	3,000 00	....
Assistant professor	3,000 00	2,250 00	750 00	....
Assistant professor	3,300 00	1,100 00	....	2,200 00
Instructor	2,200 00	1,500 00	700 00	....
Instructor	2,700 00	550 00	2,150 00	....
Instructor	2,400 00	600 00	1,800 00	....
Instructor	2,400 00	2,400 00	....	....
Graduate assistant	800 00	800 00	....	....
Assistant in farm crops	2,300 00	....	750 00	1,550 00
Clerk	1,300 00	650 00	650 00	....
Department of soils:				
Professor	5,000 00	2,500 00	2,500 00	....
Associate professor	3,600 00	2,400 00	1,200 00	....
Assistant professor	2,600 00	1,700 00	900 00	....
Instructor	2,300 00	1,550 00	750 00	....
Research associate in soils	3,200 00	....	3,200 00	....
Research associate in soils	3,800 00	....	3,800 00	....
Research associate in soils	3,400 00	....	2,200 00	1,200 00
Research associate in soils	3,200 00	....	1,600 00	1,600 00
Clerk	1,350 00	....	675 00	675 00

TABLE No. 10.—Continued.

	Rate per year.	Classification.		Extension.
		Current.	Experiment Station.	
Department of entomology:				
Professor	$4,700 00	(a)$3,100 00	$1,600 00	
Assistant professor	2,800 00	1,400 00	1,400 00	
Instructor	3,400 00	1,900 00	1,500 00	
Instructor	1,800 00	1,800 00		
Instructor	1,050 00	1,050 00		
Instructor apiculture	800 00	800 00		
Graduate assistant	800 00	800 00		
Stenographer	1,200 00	1,200 00		
Special courses:				
Director	2,000 00	2,000 00		
Department of history:				
Professor	5,000 00	5,000 00		
Assistant professor	2,500 00	2,500 00		
Stenographer	650 00	650 00		
Experiment station chemistry:				
Chemist	4,500 00		4,500 00	
Research associate in chemistry	3,800 00		3,800 00	
Research assistant in chemistry	2,800 00		2,800 00	
Research assistant in chemistry	3,200 00		3,200 00	
Assistant in chemistry	1,800 00		1,800 00	
Assistant in chemistry	2,200 00		2,200 00	
Assistant in chemistry	1,800 00		1,800 00	
Clerk	1,350 00		1,350 00	
Inspector in feeds and fertilizer	2,000 00		2,000 00	
Inspector in feeds and fertilizer	2,000 00		2,000 00	
Division of extension:				
Administration:				
Director	4,200 00			$4,200 00
Assistant director	2,800 00			2,800 00
Clerk	1,600 00			1,600 00
Stenographer	600 00			600 00
Home management demonstration:				
Specialist	3,200 00			3,200 00
Specialist	3,200 00			3,200 00
Specialist	3,200 00			3,200 00
State leader	2,000 00			2,000 00
Stenographer	1,200 00			1,200 00
Boys and girls clubs:				
State leader	2,120 00			2,120 00
Assistant	2,460 00			2,460 00
Assistant	1,920 00			1,920 00
Assistant	1,520 00			1,520 00
Assistant	2,600 00			2,600 00
Stenographer	1,200 00			1,200 00
Stenographer	1,200 00			1,200 00
Farm crops:				
Extension specialist	2,800 00			2,800 00
Stenographer	1,300 00			1,300 00
Live stock:				
Specialist	3,200 00			3,200 00
Specialist	1,400 00			1,400 00
Horticulture:				
Stenographer	600 00			600 00
Potatoes and vegetables:				
Specialist	2,500 00			2,500 00
Stenographer	600 00			600 00
Control insect pests:				
Specialist	2,000 00			2,000 00
Specialist	1,800 00			1,800 00

TABLE No. 10.—Continued.

	Rate per year.	Classification.		Extension.
		Current.	Experiment Station.	
Household engineering:				
Specialist	$3,200 00			$3,200 00
Markets:				
Assistant	3,200 00			3,200 00
Assistant field agent	3,500 00			3,500 00
Extension specialist	2,600 00			2,600 00
Extension specialist	3,600 00			3,600 00
Poultry:				
Specialist	2,800 00			2,800 00
Farm management demonstration:				
Stenographer	600 00			600 00
County agents:				
State leader	2,500 00			2,500 00
Superintendent	2,400 00			2,400 00
Stenographer	1,300 00			1,300 00
Stenographer	600 00			600 00
Stenographer	1,200 00			1,200 00
Agent, Alger County	1,200 00			1,200 00
Agent, Allegan County	1,200 00			1,200 00
Agent, Alpena County	1,200 00			1,200 00
Agent, Antrim County	1,200 00			1,200 00
Agent, Baraga County	1,200 00			1,200 00
Agent, Barry County	1,200 00			1,200 00
Agent, Benzie County	1,200 00			1,200 00
Agent, Berrien County	1,200 00			1,200 00
Agent, Branch County	1,200 00			1,200 00
Agent, Calhoun County	1,200 00			1,200 00
Agent, Charlevoix County	1,200 00			1,200 00
Agent, Cheboygan County	1,200 00			1,200 00
Agent, Chippewa County	1,200 00			1,200 00
Agent, Clinton County	1,200 00			1,200 00
Agent, Delta County	1,200 00			1,200 00
Agent, Dickinson County	1,200 00			1,200 00
Agent, Eaton County	1,200 00			1,200 00
Agent, Emmett County	1,200 00			1,200 00
Agent, Genesee County	1,200 00			1,200 00
Agent, Gladwin County	1,200 00			1,200 00
Agent, Gogebic County	1,200 00			1,200 00
Agent, Houghton County	1,200 00			1,200 00
Agent, Jackson County	1,200 00			1,200 00
Agent, Kalamazoo County	1,200 00			1,200 00
Agent, Kalkaska County	1,200 00			1,200 00
Agent, Kent County	1,200 00			1,200 00
Agent, Lapeer County	1,200 00			1,200 00
Agent, Lenawee County	1,200 00			1,200 00
Agent, Livingston County	1,200 00			1,200 00
Agent, Luce County	1,200 00			1,200 00
Agent, Macomb County	1,200 00			1,200 00
Agent, Manistee County	1,200 00			1,200 00
Agent, Marquette County	1,200 00			1,200 00
Agent, Mason County	1,200 00			1,200 00
Agent, Mecosta County	1,200 00			1,200 00
Agent, Menominee County	1,200 00			1,200 00
Agent, Missaukee County	1,200 00			1,200 00
Agent, Montcalm County	1,200 00			1,200 00
Agent, Muskegon County	1,200 00			1,200 00
Agent, Oakland County	1,200 00			1,200 00
Agent, Ogemaw County	1,200 00			1,200 00
Agent, Otsego County	1,200 00			1,200 00
Agent, Ottawa County	1,200 00			1,200 00
Agent, Saginaw County	1,200 00			1,200 00
Agent, Schoolcraft County	1,200 00			1,200 00
Agent, St. Clair County	1,200 00			1,200 00
Agent, St. Joseph County	1,200 00			1,200 00
Agent, Tuscola County	1,200 00			1,200 00
Agent, Van Buren County	1,200 00			1,200 00
Agent, Washtenaw County	1,200 00			1,200 00
Agent, Wayne County	1,200 00			1,200 00
Agent, Wexford County	1,200 00			1,200 00
Agent, Huron County	1,200 00			1,200 00
Agent, Shiawassee County	1,200 00			1,200 00

TABLE No. 10.—Concluded.

	Rate per year.	Classification.		Extension.
		Current.	Experiment Station.	
Home demonstration agents:				
Assistant leader	$3,200 00	....	....	$3,200 00
Stenographer	600 00	....	....	600 00
Agent, Allegan County	1,000 00	....	....	1,000 00
Agent, Chippewa County	1,000 00	....	....	1,000 00
Agent, Dickinson County	1,000 00	....	....	1,000 00
Agent, Gogebic County	1,000 00	....	....	1,000 00
Agent, Kalamazoo County	1,000 00	....	....	1,000 00
Agent, Manistee County	1,000 00	....	....	1,000 00
Agent, Oakland County	1,000 00	....	....	1,000 00
Agent, Wayne County	1,000 00	....	....	1,000 00
Boys' and Girls' Club Agents:				
Agent, Calhoun County	600 00	....	....	600 00
Agent, Cheboygan County	600 00	....	....	600 00
Agent, Eaton County	600 00	....	....	600 00
Agent, Genesee County	600 00	....	....	600 00
Agent, Lenawee County	600 00	....	....	600 00
Agent, Saginaw County	600 00	....	....	600 00
Agent, Washtenaw County	600 00	....	....	600 00
Total	$892,610 00	$595,615 00	$123,000 00	$173,995 00
Vocational teacher training:				
Director	3,200 00	....	3,200 00	....
Associate professor agricultural education	3,200 00	....	3,200 00	....
Associate professor home economics	3,200 00	....	3,200 00	....
Critic teacher home economics	2,400 00	....	2,400 00	....
Instructor	1,000 00	....	1,000 00	....
Clerk	700 00	....	700 00	....
Total	$906,310 00	....	$13,700 00	....

(a) House in addition.
(b) Room in addition.

TABLE NO. II.—*Salaries Experiment Station, fiscal year ending June 30, 1921.*

Director	$2,749 70
Assistant to director	504 20
Animal pathologist	2,000 00
Bacteriologist	1,600 00
Research associate in bacteriology	3,200 00
Research associate in bacteriology	2,200 00
Research associate in bacteriology	799 80
Research associate in bacteriology	3,600 00
Research associate in bacteriology	2,200 00
Research assistant in bacteriology	2,600 00
Research assistant in bacteriology	1,600 00
Botanist	900 00
Research associate in botany	1,899 90
Research associate in plant physiology	2,050 00
Research assistant in botany	2,400 00
Research assistant in botany	2,600 00
Research assistant in botany	2,100 00
Chemist	4,500 00
Research associate in chemistry	3,800 00
Research assistant in chemistry	3,200 00
Research assistant in chemistry	2,800 10
Assistant in chemistry	1,800 00
Assistant in chemistry	2,200 00
Assistant in chemistry	1,800 00
Inspector of feeds and fertilizer	2,000 00
Inspector of feeds and fertilizer	2,000 00
Animal husbandman	1,400 00
Assistant animal husbandman	700 00
Research assistant dairy husbandry	2,800 00
Research assistant dairy husbandry	2,400 00
Assistant in dairying	1,500 00
Assistant in dairying	1,700 00
Entomologist	1,600 00
Research associate in entomology	1,500 00
Research assistant in entomology	1,400 00
Farm crops experimenter	1,500 00
Research associate plant breeding	3,000 00
Research assistant farm crops	750 00
Research assistant farm crops	750 00
Research assistant farm crops	1,800 00
Research assistant farm crops	2,150 00
Research assistant farm crops	525 00
Research assistant farm mechanics	1,200 00
Research assistant farm mechanics	1,300 00
Forestry experimenter	1,000 00
Horticulturist	1,500 00
Research associate horticulture	2,800 00
Assistant in horticulture	500 00
Poultry husbandman	850 00
Assistant in poultry	700 00
Soils physicist	2,500 00
Research associate in soils	3,200 00
Research associate in soils	3,799 80
Research associate in soils	1,600 00
Research associate in soils	900 00
Research associate in soils	2,200 00
Research assistant in soils	1,200 00
Assistant in soils	750 00
Librarian	400 00
Secretary	500 00
Cashier	500 00
Bookkeeper	400 00
Bulletin clerk	1,350 00
Stenographer	675 00
Stenographer	675 00
Stenographer	450 00
Stenographer	650 00
Stenographer	800 00
Stenographer	750 00
Stenographer	689 70
Stenographer	675 00
Stenographer	403 30
Assistant in horticulture	450 00
Research assistant in dairy	500 00
Research assistant in horticulture	1,143 30
Farm mechanics experimenter	789 96
Foreman farm crops	970 20
Superintendent Graham horticultural experiment station	2,016 60
Superintendent Upper Peninsula experiment station	2,475 00
Superintendent South Haven experiment station	1,122 60
Fibre investigator	150 00
	$29,114 56

TABLE No. 12.—*Salaries Extension fiscal year ending June 30, 1921.*

Administration:	
Director	$4,200 00
Assistant director	2,800 00
Clerk	1,600 00
Stenographer	892 10
Stenographer	600 00
Publicity agent	2,200 00
Accountant	1,750 00
County agents:	
State leader	2,500 00
Superintendent	2,400 00
Agent, Alger County	1,200 00
Agent, Allegan County	1,200 00
Agent, Alpena County	1,200 00
Agent, Antrim County	1,200 00
Agent, Baraga County	1,200 00
Agent, Barry County	1,200 00
Agent, Benzie County	1,200 00
Agent, Berrien County	1,200 00
Agent, Branch County	1,200 00
Agent, Calhoun County	1,200 00
Agent, Charlevoix County	1,200 00
Agent, Cheboygan County	401 10
Agent, Cheboygan County	450 03
Agent, Chippewa County	1,200 00
Agent, Clinton County	1,200 00
Agent, Delta County	1,200 00
Agent, Dickinson County	1,200 00
Agent, Eaton County	1,200 00
Agent, Emmet County	1,200 00
Agent, Genesee County	1,200 00
Agent, Gladwin County	1,200 00
Agent, Gogebic County	1,200 00
Agent, Grand Traverse County	401 10
Agent, Houghton County	1,200 00
Agent, Huron County	600 00
Agent, Iron County	373 30
Agent, Jackson County	1,200 00
Agent, Kalamazoo County	1,200 00
Agent, Kalkaska County	1,200 00
Agent, Kent County	1,200 00
Agent, Lapeer County	798 90
Agent, Lapeer County	401 10
Agent, Lenawee County	1,200 00
Agent, Livingston County	1,200 00
Agent, Luce County	1,200 00
Agent, Macomb County	1,200 00
Agent, Manistee County	1,200 00
Agent, Marquette County	1,200 00
Agent, Mason County	1,200 00
Agent, Mecosta County	1,200 00
Agent, Menominee County	1,200 00
Agent, Missaukee County	202 20
Agent, Missaukee County	600 00
Agent, Monroe County	1,034 65
Agent, Montcalm County	202 20
Agent, Montcalm County	600 00
Agent, Montcalm County	198 90
Agent, Muskegon County	1,200 00
Agent, Muskegon County	401 10
Agent, Oakland County	998 90
Agent, Ogemaw County	1,200 00
Agent, Otsego County	1,200 00
Agent, Ottawa County	1,200 00
Agent, Ottawa County	40 00
Agent, Presque Isle County	998 90
Agent, Presque Isle County	154 95
Agent, Saginaw County	1,200 00
Agent, Schoolcraft County	1,200 00
Agent, Shiawassee County	703 30
Agent, Shiawassee County	695 60
Agent, St. Clair County	796 70
Agent, St. Clair County	1,200 00
Agent, St. Joseph County	1,200 00
Agent, Tuscola County	1,200 00
Agent, Van Buren County	1,200 00
Agent, Washtenaw County	1,200 00
Agent, Wayne County	1,200 00
Agent, Wexford County	1,200 00
Stenographer	551 00
Stenographer	1,300 00
Stenographer	1,200 00

TABLE No. 12.—Continued.

Home demonstration agents:	
Assistant leader	$3,200 00
Agent, Allegan County	1,000 00
Agent, Chippewa County	1,000 00
Agent, Dickinson County	1,000 00
Agent, Gogebic County	1,000 00
Agent, Houghton County	663 90
Agent, Kalamazoo County	1,000 00
Agent, Manistee County	1,000 00
Agent, Oakland County	1,000 00
Agent, Ottawa County	165 80
Agent, St. Clair County	500 00
Agent, Wayne County	1,000 00
Stenographer	649 00
Boys' and girls' club work:	
State leader	2,120 00
Assistant	2,460 00
Assistant	1,726 10
Assistant	1,520 00
Assistant	1,100 00
Assistant	2,600 00
Assistant	645 35
Agent, Baraga County	200 50
Agent, Branch County	300 00
Agent, Calhoun County	201 70
Agent, Cheboygan County	600 00
Agent, Eaton County	600 00
Agent, Genesee County	600 00
Agent, Gogebic County	300 00
Agent, Hillsdale County	300 00
Agent, Iron County	200 50
Agent, Iron County	201 70
Agent, Jackson County	50 50
Agent, Jackson County	50 00
Agent, Luce County	300 00
Agent, Lenawee County	600 00
Agent, Macomb County	101 00
Agent, Osceola County	50 50
Agent, Saginaw County	600 00
Agent, Schoolcraft County	101 00
Agent, Van Buren County	50 50
Agent, Washtenaw County	600 00
Agent, Washtenaw County	151 50
Agent, Wayne County	499 50
Agent, Wayne County	100 50
Stenographer	168 78
Stenographer	1,200 00
Stenographer	1,098 90
Home economics:	
State leader	1,168 50
Specialist	3,200 00
Specialist	3,200 00
Specialist	3,200 00
Stenographer	1,200 00
Farm crops:	
Specialist	2,200 00
Specialist	2,800 00
Specialist	1,550 00
Stenographer	1,300 00
Live stock:	
Specialist	3,200 00
Specialist	1,400 00
Specialist	75 00
Horticulture:	
Specialist	1,300 00
Specialist	935 90
Stenographer	600 00
Potatoes and vegetables:	
Specialist	2,700 00
Specialist	2,500 00
Stenographer	600 00
Control insect pests:	
Specialist	2,000 00
Specialist	1,800 00

TABLE 12.—*Concluded.*

Farm management demonstration:	
Specialist	$750 00
Stenographer	600 00
Household engineering:	
Specialist	2,808 71
Markets:	
Specialist	2,431 25
Specialist	2,600 00
Specialist	2,910 30
Specialist	454 95
Poultry:	
Specialist	1,251 25
Stenographer	150 00
Soils:	
Specialist	1,600 00
Specialist	1,200 00
Stenographer	675 00
Total	$178,384 12

TABLE No. 13.—*Income of the Michigan Agricultural College from all outside sources from the date of its foundation to the present time.*

Year.	From State legislature.			From U. S. Congress.				Total.
	For current expenses.	For special purposes.	Land sales, salt spring and swamp land grants.	Morrill act of 1862, interest from land grant and trespass.	Hatch act of 1887, and Adams act of 1906, experiment station.	Morrill act of 1890, supplementary endowment.	Smith Lever act of 1914, extension.	
1855			$56,320 00					$56,320 00
1856								
1857	$40,000 00							40,000 00
1858								
1859	37,500 00							37,500 00
1860								
1861	6,500 00		152 25					6,652 25
1862	10,000 00		218 97					10,218 97
1863	9,000 00		407 80					9,407 80
1864	9,000 00		726 09					9,726 09
1865	15,000 00		1,156 61					16,156 61
1866	15,000 00		1,094 27					16,094 27
1867	20,000 00		7,608 38					27,608 38
1868	20,000 00		592 49					20,592 49
1869	20,000 00	$30,000 00	17,559 00	$58 96				67,617 96
1870	20,000 00		1,320 02	2,720 93				24,040 95
1871	18,250 00	10,500 00	4,135 72	3,785 54				36,671 26
1872	18,250 00	3,000 00	217 05	7,175 65				28,642 70
1873	21,796 00	15,602 00	10 13	11,059 06				48,467 19
1874	13,000 00	15,602 00	150 13	14,061 98				42,814 11
1875	7,638 00	7,755 50	144 53	14,446 14				29,984 17
1876	7,638 00	6,755 50	1,773 09	16,830 17				32,996 76
1877	6,150 00	30,686 80	979 06	15,172 86				52,988 72
1878	6,150 00	5,686 80	826 60	15,807 09				28,470 49
1879	4,971 80	16,068 32	712 22	16,978 22				38,730 56
1880	4,971 80	7,068 32	797 55	17,837 24				30,674 91
1881	7,249 00	43,720 50	461 95	20,935 25				72,366 70
1882	7,249 00	8,945 50	358 46	22,507 45				39,060 41
1883	8,385 00	23,793 00	391 95	30,749 60				63,319 52
1884	8,385 00	10,526 00	1,259 90	27,909 72				48,080 65

1885		35,103 00	187 50	29,770 40				65,060 90
1886		22,617 00		30,461 04				53,078 04
1887		*44,040 00	198 20	†24,611 37				68,849 57
1888		30,752 50	144 20	32,406 60	15,000 00			78,303 30
1889		*20,973 00	10 50	31,322 69	15,000 00			67,306 19
1890		*27,172 00	238 50	32,360 64	15,000 00	15,000 00		89,771 14
1891		22,947 50	37 38	34,750 54	15,000 00	16,000 00		88,735 42
1892		22,947 50	137 38	34,948 12	15,000 00	17,000 00		90,033 00
1893		18,862 50	10 50	37,927 04	15,000 00	18,000 00		89,800 04
1894		18,862 50	433 59	44,527 26	15,000 00	19,000 00		97,823 35
1895		‡19,000 00	10 50	45,301 85	15,000 00	20,000 00		99,312 35
1896		‡16,000 00		43,886 40	15,000 00	21,000 00		95,886 40
1897		§17,700 00		43,779 54	15,000 00	22,000 00		98,479 54
1898		‖17,500 00		47,508 28	15,000 00	23,000 00		103,008 28
1899		¶8,750 00	705 00	52,526 11	15,000 00	24,000 00		100,981 11
1900		¶72,500 00	175 00	72,298 38	15,000 00	25,000 00		184,973 38
1901††		¶72,500 00		63,976 79	15,000 00	25,000 00		176,476 79
1902	100,000 00	**1,000 00		64,081 81	15,000 00	25,000 00		205,081 81
1903	100,000 00	**1,000 00		65,573 90	15,000 00	25,000 00		206,573 90
1904	100,000 00	**1,000 00	61 19	67,312 37	15,000 00	25,000 00		208,373 56
1905	100,000 00	*81,000 00		72,035 32	15,000 00	25,000 00		293,035 32
1906	157,810 00	*15,000 00		70,286 56	15,000 00	25,000 00		283,096 56
1907	173,410 00	**1,000 00		70,155 22	23,691 60	25,000 00		293,256 82
1908	173,410 00	**1,000 00		70,385 79	23,326 10	30,000 00		298,121 89
1909	173,410 00	**1,000 00		69,527 13	26,000 00	35,000 00		304,937 13
1910	173,410 00	**1,000 00		71,109 49	28,000 00	40,000 00		313,519 49
1911	173,410 00	**1,000 00		70,304 15	30,000 00	45,000 00		319,714 15
1912	228,800 00	**1,000 00		70,265 32	30,000 00	50,000 00		380,065 32
1913	228,800 00	**1,000 00		70,289 30	30,000 00	50,000 00		380,089 30
1914	228,800 00	**1,000 00		71,324 94	30,000 00	50,000 00		381,124 94
1915	308,147 25	**1,000 00		70,385 46	30,000 00	50,000 00	10,000 00	469,532 71
1916	560,000 00	**1,000 00		71,391 56	30,000 00	50,000 00	28,032 37	740,423 93
1917	560,000 00	**1,000 00		69,437 43	30,000 00	50,000 00	43,059 35	753,496 78
1918	560,000 00	**1,000 00		70,502 10	30,000 00	50,000 00	58,086 33	769,588 43
1919	560,000 00	**1,000 00		70,662 44	30,000 00	50,000 00	73,113 31	784,775 75
1920	900,000 00	***35,000 00		70,736 34	30,000 00	50,000 00	133,221 23	1,218,957 57
1921	900,000 00	***35,000 00		70,685 37	30,000 00	50,000 00	148,172 80	1,233,858 17
Totals	$6,821,490 85	$905,937 74	$101,723 66	$2,336,850 91	$716,017 70	$1,045,000 00	$493,685 39	$12,420,706 25

*Including appropriation for weather service.
†October 1, 1886, to June 30, 1887, nine months.
‡Including $5,000 for institutes and $1,000 for weather service.
‖Including $5,500 for institutes and $1,000 for weather service.
§Including $2,750 for institutes and $500 for weather service.
††To June 30.
**Weather service.
¶Including $5,500 for institutes and $1,000 for weather service.
***Extension

SUMMARY OF COLLEGE INVENTORY, JUNE 30, 1921.

Buildings and lands:	
College farm and park, 671 acres	$67,100 00
Lots 2, 3 and 4, River Bend addition	4,000 00
Athletic field and drive, 13 acres	1,300 00
320 acres swamp land	960 00
Purchased C. D. Woodbury farm, 1916, 308.82 acres	38,602 50
1 acre more or less formerly belonging to Harrison, adjacent to campus	2,000 00
Purchased in 1913, 27 acres	3,375 00
50,359 acres, remainder of land grant not formerly carried in inventory	251,795 00
Buildings:	
Library and museum, built 1881	22,000 00
Wells Hall, rebuilt 1905-06	55,000 00
Abbot Hall, built 1888, addition in 1896	15,000 00
Chemical laboratory, built in 1871, south end addition in 1881, east end addition in 1911	35,000 00
Veterinary laboratory, built in 1885	5,000 00
Horticultural laboratory, built 1888	7,000 00
Entomological laboratory, built 1889, improved 1897	7,500 00
Botanical laboratory, built 1892, improved 1909	20,000 00
Armory, built 1885	6,000 00
Greenhouse and stable, built 1873, 1879, rebuilt 1892 and 1902	6,000 00
Presidents and two frame dwellings, built 1874	12,000 00
Six brick dwellings, built 1857, 1879 and 1884	18,000 00
One frame house, built 1885	3,500 00
One frame house	2,500 00
Howard Terrace dwelling, built 1888	13,000 00
Farm house dwelling, built 1869	2,000 00
Herdsman's dwelling, built 1867	400 00
Horticultural barn and shed, built 1868, 1875 and 1877	1,200 00
Bull barn, rebuilt 1905	1,500 00
Sheep barn, rebuilt 1906	2,500 00
Horse barn, built 1906	5,000 00
Grade herd barn, rebuilt 1905	4,000 00
Piggery, rebuilt 1907	1,500 00
Dairy barn, rebuilt 1900	4,000 00
Farm mechanics building, built 1881	1,500 00
Poultry house, built 1906	1,000 00
Incubator house, built 1906	500 00
Poultry house, built 1907	1,500 00
Three poultry houses, built 1907	300 00
Ten brooder houses, built 1908	250 00
Corn barn, built 1878	400 00
Stable, built 1894	200 00
Brick work shop, built 1857	500 00
Observatory, built 1880	100 00
Bath house and fittings, built 1902-3	17,000 00
Hospital, built 1894	3,000 00
Waiting room and book store, built 1902	1,700 00
One silo	200 00
Womens building, built 1909	91,000 00
Forestry building, built 1900	15,000 00
Bacteriological building, built 1902	27,000 00
Power house, built 1904	25,000 00
Tunnel system, built 1904	45,000 00
Cold storage, rebuilt 1905	2,000 00
Iron bridge over Cedar River, built 1888	1,500 00
Bridge to athletic field	500 00
Manure shed	600 00
Four hospital cottages, built 1909	6,000 00
Agricultural building, built 1909	182,000 00
Tile silo, No. 1	500 00
Piggery for serum production	1,000 00
Two tenant dwellings, built 1912	2,400 00
New dairy building, built 1913	55,000 00
Tile silo, No. 2	600 00
Tile silo, No. 3	600 00
2 cement stave silos	800 00
Forestry packing house	1,000 00
Veterinary laboratory, 1914	33,000 00
Special chemical laboratory	800 00
R. E. Olds Hall of engineering, built 1916	155,000 00
Shop No. 1, built 1916	26,400 00
Shop No. 2, built 1916	15,750 00
Shop No. 3, built 1916	14,500 00
Gymnasium, built 1916	220,000 00
Total	$1,569,832 50

SUMMARY OF COLLEGE INVENTORY.—*Concluded.*

Division of agriculture:	
Department of agricultural education	$703 88
Department of animal husbandry	32,000 47
Department of dairy husbandry	38,673 57
Office of the dean	1,186 94
Department of farm crops	3,140 72
Department of farm and horses	36,194 81
Department of farm mechanics	13,677 16
Department of forestry	15,224 45
Department of horticulture	5,053 96
Department of poultry husbandry	11,859 63
Department of soils	10,254 31
Division of engineering:	
Department of civil engineering	18,856 62
Office of the dean	2,834 45
Department of drawing and design	10,285 25
Department of electrical engineering	20,462 32
Department of mechanical engineering	88,019 03
Division of experiment station:	
Section of buildings and lands	71,075 00
Section of bacteriology	13,151 72
Section of botany	8,051 76
Bulletin room	2,419 05
Section of chemistry	15,914 33
Office of the director	653 62
Section of entomology	8,399 85
Section of farm crops	3,025 80
Section of Graham horticultural experiment station	43,689 75
Section of horticulture	2,835 58
Section of library	7,649 78
Section of soils	6,608 75
Section of South Haven experiment station	1,861 02
Section of Upper Peninsula experiment station	14,503 23
Division of extension	19,770 99
Division of home economics:	
Dean of women	22,380 12
Department of domestic art	4,650 99
Department of domestic science	6,585 04
Division of science and letters:	
Department of bacteriology	19,274 23
Department of botany	28,500 37
Department of chemistry	68,343 19
Department of economics	254 50
Department of English	1,347 74
Department of entomology	11,195 95
Department of history	648 75
Department of mathematics	896 45
Department of meteorology	305 09
Department of military science	8,392 68
Department of music	2,300 00
Department of physical training	14,766 98
Department of physics	12,944 98
Department of zoology and physiology	33,239 37
Division of veterinary science:	
Department of anatomy	17,529 53
Department of animal pathology	6,933 95
Department of surgery and clinic	3,874 58
Department of veterinary medicine	5,598 40
Miscellaneous:	
Abortion barns	734 75
Alumni recorder's office	1,136 10
Carpenter shop	4,418 40
Health service	1,921 71
Hospital	3,598 86
Library	81,454 81
Michigan weather service property	845 00
Orchard and nursery inspection	1,247 55
Paint shop	2,309 18
Post office	1,383 21
President's office	649 19
Registrar's office	1,240 09
Secretary's office	7,672 31
Seed laboratory	845 71
Soil house	765 45
Store	2,693 26
Sundry	3,937 00
Vocational teacher training	627 53
Water heat and light	66,650 34
Wells Hall	2,476 26
Total	$984,607 40

REPORT OF THE DEAN OF AGRICULTURE.

To President F. S. Kedzie:

During this college year the greatest depreciation in prices of farm products occurred. This tended to diminish the general interest in agriculture and depress educational efforts along this line, because of lack of funds to support young men and women in educational institutions. Despite this fact our enrollment was very gratifying indeed, including a total of 737 in the regular four year course and 500 in the special short courses, making a total of 1237 for the year including the summer session. Continued interest was manifested in the re-establishment of graduate study. During this year I participated in presenting a vocational guidance course to freshmen during the winter term and also the subject of Farm Management for short course students.

The following statistics present a classified statement of the enrollment within the division during the year:

Advanced Degree	7	
Graduate Students	10	
Graduating Class	106	
Seniors	87	
Juniors	87	
Sophomores	123	
Freshmen	197	
Specials	21	
Summer Session	99	
		737
Sixteen Weeks' Course in General Agriculture, First Year	88	
Sixteen Weeks' Course in General Agriculture, Second Year	56	
Eight Weeks' Course in General Agriculture, First Year	47	
Eight Weeks' Course in General Agriculture, Second Year	19	
Eight Weeks' Course in Dairy Manufactures	16	
Eight Weeks' Course in Dairy Production	12	
Eight Weeks' Course in Horticulture	20	
Eight Weeks' Course in Farm Mechanics	18	
Four Weeks' Course in Poultry	25	
Two Weeks' Course in Cow Testing and Dairy Barn Management	19	
Two Weeks' Course for Ice Cream Makers	19	
First Truck and Tractor Course	82	
Second Truck and Tractor Course	79	
		500
		1,237

As usual many meetings of farmers and stockmen were held at the institution including the State Association of Live Stock Breeders and Feeders, and the Crop Improvement Association. These activities were largely stimulated and directed by the personnel of the division. Much aid is given

these associations through official representation largely in the form of secretaryships. A number of public auction sales of pure-bred live stock were held at the College during the year, thus bringing to the institution many stockmen who would not have been attracted by other interests. The Annual Farmers' Week was conceded by all to have been the greatest success of any. A special feature worthy of mention included the parade representing the interests of all divisions of the institution.

We are still feeling more and more the cramped condition of the Agricultural Building, which, of necessity, has to accommodate numerous departments not included within the division. We still feel that relief cannot be adequately furnished until a livestock amphitheatre and farm mechanics building are provided. The need of removing the piggery to quarters across the river is constantly increasing.

During this year the Department of Farm Management has gotten under way and is now furnishing service along investigational and educational lines so long badly needed. It is most earnestly hoped that these activities may provide a long felt need, by way of service to the student and farmer.

The Dairy department is undergoing a reorganization under the able direction of Prof. O. E. Reed, who assumed charge of the department May 1st.

The Soils department has assumed additional responsibilities in connection with its State soil survey work and has already achieved creditable success in this line.

Our endeavor continues with a policy devised to eventually place all departments on an equally strong and symmetrical basis.

Respectfully submitted,

R. S. SHAW,
Dean of Agriculture.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

President F. S. Kedzie, College:

Dear Sir:

I have the honor to submit the following report of the Department of Animal Husbandry for the year ending June 30, 1921.

The following table gives a summary of the teaching work carried by the staff the past year:

Fall term.	Sect.	Days per wk.	Hrs. per week.	No. in class.	Teacher.
A. H. I	1–4	3	5	64	W. E. J. Edwards.
A. H. I	5–8	3	5	68	W. E. J. Edwards.
A. H. I	9–12	3	5	61	G. A. Brown.
A. H. II		3	5	69	W. E. J. Edwards.
A. H. V		5	8	40	G. A. Brown.
Short course:					
A. H. IV		5	5	55	W. E. J. Edwards.
A. H. I		5	10	70	E. B. Hill.
Winter term:					
A. H. VI	1	5	8	14	G. A. Brown.
A. H. VI	2	5	8	25	G. A. Brown.
A. H. IV	1	5	5	78	Brown and Edwards.
Short course:					
Study of breeds		4	8	38	W. E. J. Edwards.
Study of types		5	10	43	E. B. Hill.
Stock judging	8 weeks	5	10	24	R. L. Mackie.
Stock judging	16 weeks	5	10	38	W. E. J. Edwards.
Feeding		5	5	43	W. E. J. Edwards.
Stock management		3	3	40	W. E. J. Edwards.
Spring term:					
A. H. VII		5	8	28	G. A. Brown.

During the fall and winter terms, Mr. E. B. Hill rendered material and valuable assistance in the work of teaching the short course classes. Even with his help, however, the work of the department was quite heavy for the personnel, necessitating larger classes than are desirable. If the student is to get the most out of his work and come in close personal contact with the instructor, a larger personnel must be provided the department. The large amount of class work during the fall and winter terms also prohibits the members of the department from assisting in any extension work or attending livestock breeders' meetings in different parts of the State.

The institution is rapidly outgrowing the capacity of our present judging pavilion and in order that we may give our students better instruction and meet the demand of the livestock men of the State for a place where they may assemble for educational purposes, it is to be earnestly hoped that the institution will be able to erect a larger stock judging pavilion within the next year.

At the present time we are feeding some steers to be exhibited at the International Live Stock Exposition at Chicago, which we feel will make a very creditable showing for the institution. However, if we are to become a serious contender for high honors and build our herds of sheep, swine and

cattle up to the standard of perfection which they should attain, it will be necessary that a larger fund be appropriated each year for the purchase of breeding stock.

We are also handicapped for room, especially with the swine. The present swine barn is not only located in too close proximity to the classrooms on the campus, but the lots surrounding it, which are used for forage purposes, have been grazed continuously by swine for fifteen years and are overflowed by the river each year making it practically impossible to conduct any forage crop experiments. I would earnestly recommend that the swine barn be moved across the river at the earliest opportunity, and not less than twenty acres be set aside for experimental work in swine production.

Respectfully submitted,
GEO. A. BROWN,
Professor of Animal Husbandry.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DAIRY DEPARTMENT.

President F. S. Kedzie,
Michigan Agricultural College,
East Lansing, Michigan.

Dear Sir:

I herewith submit a brief report of the work of the Department of Dairy Husbandry for the year ending June 30, 1921.

Associate Professor J. E. Burnett was appointed acting head of the department on the resignation of Professor A. C. Anderson and held this position until May 1st, 1921, when O. E. Reed was appointed Professor of Dairy Husbandry.

The personnel of the department has been as follows:

O. E. Reed, Professor of Dairy Husbandry. Appointed May 1st, 1921.
J. E. Burnett, Associate Professor of Dairy Husbandry.
O. T. Goodwin, Associate Professor of Dairy Manufactures.
H. E. Dennison, Assistant Professor of Dairy Husbandry. Appointed April 1st, 1921.
C. E. Newlander, Assistant Professor of Dairy Manufactures. Appointed January 1st, 1921.
R. W. Wyant, Instructor in Dairy Manufactures. Resigned September 1st 1920.
Hilda Kellner, Instructor in Dairy Manufactures.
E. B. Hint, Superintendent of Official Testing.
F. T. Riddell, Research Assistant in Dairying. Transferred to Dept. of Farm Management, March 1st, 1921.
Stanley J. Brownell, Research Assistant in Dairying.
Wm. J. Kurtz, Assistant in Dairying. Transferred to Dept. of Farm Management, March 1st, 1921.
A. J. Howland, Assistant in Dairying. Transferred to Dept. of Farm Management, March 1st, 1921.

ADVANCED REGISTRY.

The official testing for the fiscal year has been very satisfactory. The year closed with 87 herds on semi-official test, representing six breeds and showing an increase over the previous year of 67.3% in the amount of semi-official work. There were 1330 seven-day records completed and reported, showing an increase over the previous year of 11.9%. In the seven-day reports are included 59 "over 30 pounds of butter".

There were six new state records made by Holstein cows as follows: Seven-day milk record for mature cow, fat records for seven-days senior three-year old class and senior four-year old class, the milk records for seven and thirty days in the junior three-year old class, and the 365 day milk record for mature cows.

The big demand for supervisors came in the middle of October and lasted until the last of May. At one time during the year fifty-three supervisors were engaged in making tests.

EXHIBITS AND FAIRS.

The department made an exhibit at the Michigan State Fair at Detroit which created considerable interest and favorable comment. An exhibit was made showing the amount of food a cow consumes to produce one hundred pounds of milk. Exhibits of feeding stuffs were displayed showing the value of high protein roughage in feeding dairy cows. A large display of dairy products also attracted a good deal of interest.

Johanna Mutual Girl No. 260901 and College Butter Boy No. 293508, two Holsteins from the College herd, were shown in open competition, with the result that Johanna Mutual Girl was awarded first prize in the aged cow class and Grand Champion Holstein Female of the Show. College Butter Boy was made Junior Champion of the Show.

The Farmers' Week exhibit at the College was so well received by producers and manufacturers that it was duplicated at Grand Rapids during the meeting of the Michigan Allied Dairy Association. Most of the credit for these exhibits belongs to Mr. Brownell and Professor Goodwin.

DAIRY BARN.

Official and semi-official tests have been continued and one cow, Colantha Mutual Queen, made an official record of over 32 pounds of butter in seven days. More farmers and dairymen have visited the dairy herd and the herd has been used more for instructional purposes during the past year, than at any other similar period.

Respectfully submitted,
O. E. REED,
Professor of Dairy Husbandry.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE FARM CROPS DEPARTMENT.

President F. S. Kedzie,
East Lansing, Michigan.

Dear Sir:

The preparation of the report of this department for the fiscal year ending June 30th, 1921, is a matter of unusual pleasure and interest, since in my estimation the efforts of the members of the department to develop stronger courses and fit our instructional work more closely to the needs of the State, have met with considerable success. Particular effort has been made to strengthen our required courses, which are foundational.

The expansion of the area of land available for the Farm Crops section for experimental purposes, has been accompanied by an increased strength along instructional lines. The close proximity of our experimental fields has enabled us to make use of our full range of crop experiments in teaching work. A very considerable proportion of the tractation work of our fall and spring courses consisted of carefully planned work in the field. It is my firm opinion that in order to get the most benefit from lecture work, reference assignments, and laboratory studies in Farm Crops, opportunity for the study of crop production and crop experiments in the field must be offered.

Briefly stated, the instructional work offered consisted of the following courses:

Farm Crops 1, Cereal Crops:—This is our foundational course in cereal crops and is required of all students of the Agricultural division. Particular effort is made to present in a broad way the agronomic importance, methods of cultivation, and other facts considered of importance relating to cereal crop production. The lectures were given by myself and the laboratory work was conducted by Mr. C. E. Cormany. Substantial additions were made to the laboratory exercises and equipment.

One-hundred and seventy students were enrolled in this course.

Farm Crops 2, Forage Crops:—The lectures in this course were given by Assistant Professor C. R. Megee, and the newly established supporting laboratory exercises were directed by him with assistance from Mr. C. E. Cormany, and senior students taking the course in Agricultural Education. Numerous new lantern slide lectures on the use of crops material, specially collected during the previous growing season, added greatly to the value of this course.

One-hundred and twenty-nine students were enrolled.

Farm Crops 3, Advanced Cereals and Grain Judging:—This course was given in the fall term, thereby making it possible to include many field trips of value. The main object of the course was to familiarize students with characteristics of good and bad seed, impurities found in the seed, the identification of varieties, and best methods of cereal seed production. Assistant Professor A. L. Bibbins was in charge of this course, assisted by Mr. C. E. Cormany and Mr. J. R. Duncan. Students enrolled forty-two.

Farm Crops 4, Advanced Forage Crops and Special Michigan Crops:—This course was given during the spring, providing opportunity for the study in the field of pasture, hay grasses, and other forage crops. The study of po-

tatoes, sugar beets, and other root crops made up part of the course, but during the coming year these crops will be covered in a new three-hour optional course for juniors. This arrangement will give more time in the spring for the consideration of forage crop problems and special crops, and enable us to give a much stronger course in potatoes, sugar beets, and other root crops. The course was given by Professor J. F. Cox and assisted by Instructor C. E. Cormany. Students enrolled thirty-four.

Farm Crops 5-A, Advanced Genetics in Relation to Plant Breeding:—A larger number of students than usual elected this course, which may be considered as sound evidence of the increased interest which is being taken in plant breeding work, as developed by Professor F. A. Spragg and Mr. E. E. Down. This course was given in the winter and was followed in the spring by Farm Crops 5-B-Plant Breeding. Six students took this course, which in view of its advanced nature may be considered a very satisfactory class.

Farm Crops 6:—The first half of this course was given over to the study of crop adaptation, ecological studies, and crop rotations and management. This part of the work was given by Professor J. F. Cox, Mr. G. W. Putnam and Mr. C. E. Cormany. The second half was given over to grain standardization and marketing work. Professor A. L. Bibbins gave this course with assistance from other members of the staff. Students enrolled, thirty eight.

The short courses in Farm Crops were given by Assistant Professor C. R. Megee, Mr. C. E. Cormany, and Mr. J. R. Duncan, and a special instructor. Ninety sixteen weeks' men and sixty-nine eight weeks' students received instruction in Farm Crops.

Respectfully submitted,
J. F. COX,
Professor of Farm Crops.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF FARM MECHANICS.

President F. S. Kedzie, College.

Dear Sir:

I have the honor to submit the following report for the year 1920-21.

That part of the report pertaining to Farm Buildings and Conveniences is given in detail by Mr. Fogle, and the matter on Power and Farm Machinery by Mr. Sauve.

It has been found necessary to devote some time to reorganizing the work of the department in order that it may be put in a position to render better service in the wide range of subjects which fall to this department. Agricultural Engineering includes applied matter from almost every field of engineering, so it has been thought best to divide the work into three groups in each of which the matter is more or less related, i. e., Buildings and Conveniences, Power and Farm Machinery, Drainage and Land Clearing.

Rearrangement of the office space into small offices for these lines of work and also for extension work, has made concentration possible.

Considerable time has been devoted to the reorganization of courses. It

has been impressed upon us for some time that to meet even in a small way the opportunities before the institution, some specialization must be made in farm mechanics. An option in farm mechanics was therefore arranged by the addition of one subject, Cement and Concrete, and by increasing the credits in three others. We now have a fairly complete group of subjects and teaching personnel. A possible addition would be the outlining course in Agricultural Engineering in which the major part of the undergraduate work is basically engineering.

Meeting the varied demands in the short courses has become a difficult problem with limited space and equipment located in several buildings. In some cases it has been necessary to carry on two laboratory sections at one time in the same room. Tools, material, and equipment require a high overhead expense for keeping in place and condition for class work under these conditions.

The attendance in the Tractor Courses was excellent considering the tractor situation. It has been our purpose in this course to train tractor operators, and to present the tractor in such way as to encourage its development from a sound business basis.

The Farm Mechanics Special Eight Weeks' Short Course had an attendance of thirteen. Good interest was shown and it is believed that the special training given in this course can be made immediately applicable to farm and home problems.

It has been my good fortune to have the heartiest cooperation in the department from all the staff, and I wish to express my appreciation of this support in the highest terms. The transfer of Bert Sangster, Laboratory Assistant, to the Mechanical Engineering department as instructor in blacksmithing upon joint recommendation of myself and Professor Dirks, has been a loss to the department but it is thought that Mr. Sangster's experience in machine shop, blacksmithing, and farm repair work should especially fit him for the position assumed.

In Farm Drainage the course of instruction has been revised and now includes the relationship of the single farm as a drainage project to the township, county, and state.

Some work in Land Clearing is to be included in the new course in Farm Drainage. It is hoped that the employment of an extension specialist, Mr. Lawrence F. Livingston, in this field will stimulate interest in it and contribute to the subject matter in the course.

POWER AND FARM MACHINERY.

The work in gas engines and tractors during the past year has been very satisfactory. The student enrollment in this work has been very gratifying to the department, and we believe the results obtained in our instructional work have been largely due to the fine spirit of cooperation of the gas engine, tractor, and accessory manufacturers who have gladly made loans to us of their equipment. We are indebted to these people as well as to Dean Bissell and Professor Dirks of the Engineering department for the splendid assistance given us in the use of their equipment.

In addition to the regular courses in gas engines given in the fall and winter terms, there were two courses offered in trucks and tractors each of four weeks duration. Out of an enrollment of 150 students attending these special classes, fifty were men of Russian parentage who were preparing themselves along mechanical lines that they may later assist their home land in a more

scientific agriculture. Foreign press reports speak highly of the instruction and treatment accorded these students by the College.

The work in farm machinery was given as usual during the spring term with a good enrollment. Considerable emphasis was placed on the new features in the development of farm machines.

FARM BUILDINGS AND CONVENIENCES.

Instruction.

The courses in Farm Buildings and Farm Conveniences for the short course and regular students were given as outlined in the catalog. Mr. H. J. Gallagher gave very efficient assistance in the work with the short courses. The lengthening of the course in Farm Buildings for regular students from three to five credits and making drawing a prerequisite, will greatly strengthen this work. A laboratory has been equipped with farm conveniences which is a material aid in presenting this work.

EXTENSION.

In cooperation with the Extension division sample books of the blue print plans available from Farm Mechanics department have been supplied to each county agent.

Respectfully submitted,

H. H. MUSSELMAN.

Professor of Farm Mechanics.

East Lansing, Mich., June 30, 1921.

REPORT OF THE DEPARTMENT OF FORESTRY.

The President, Michigan Agricultural College.

Sir: I have the honor to submit the following report for the Department of Forestry for the year ending June 30, 1921.

The work of the department has been very successful during the past year. The course was thoroughly revised. A number of new subjects were introduced and the number of credits called for in many other subjects was changed. This revision has worked out most satisfactorily and has, I believe, greatly strengthened the course.

Mr. G. A. Garratt was appointed Instructor in Forestry to take the place of Mr. F. H. Sanford, who resigned on December 31. The teaching work for the year was as follows:

	Number of classes.	Number of students.
A. K. Chittenden	7	242
P. L. Buttrick	7	106
F. H. Sanford	1 (Fall term)	6
G. A. Garratt	7 (Winter and spring term)	116

The forestry summer school was held on the lands of the East Jordan Lumber Company, near Green River. The company furnished us with the use of buildings for sleeping quarter, mess hall, kitchen and classroom and also

furnished practically all of the equipment needed to operate the camp, and I wish to express our appreciation of their courtesy. There were twenty-seven students in attendance and the quality of the work accomplished was very high. The summer school session in forestry was reduced to four weeks which, since the work is required, is in many respects better than a seven weeks' course, as it allows the student more time to himself during the summer. The work consists of field work running steadily from 6:00 A. M. to 5:00 P. M. so a very large amount of work can be accomplished during the four weeks.

The forest nursery was operated as usual; planting stock amounting to 99,000 trees having been shipped during the year. The yield of maple syrup in the sugar bush was that of an average season, and a considerable amount of cord wood was removed in thinnings in the south woods. The wood lots are both in excellent condition.

During Farmers' Week a wood lot conference was held at the College. The meeting was very successful and will, I hope, be followed by others of the same kind.

The number of students in forestry has increased considerably during the last two years and we find ourselves badly hampered for lack of sufficient laboratory space. Much of our equipment cannot be used to the best advantage for lack of room, and the students are very much crowded.

I wish to express my appreciation of your many helpful suggestions and encouragement during the year.

Respectfully submitted,
A. K. CHITTENDEN,
Professor of Forestry.

East Lansing, Mich., June 30, 1921.

REPORT OF THE DEPARTMENT OF HORTICULTURE.

To President F. S. Kedzie:

Dear Sir:

It is a pleasure to report that the work for the past year has been marked by new improvements and developments in the Horticultural department and that the year as a whole, has been a very successful one.

At the beginning of the school year we were fortunate in obtaining the services of Mr. R. E. Marshall, a graduate of the Nebraska State Agricultural College and a post-graduate in Horticulture of Oregon. During recent years his work has been along extension lines as Director of Horticultural Extension in Virginia. The services of Dr. Newton L. Partridge have also been utilized in teaching a few courses during the winter months which did not interfere with his experimental work.

We offered for the first time a course in the Geography of Horticulture in the fall term which proved very interesting and instructive. The course in Commercial Horticulture given during the winter term was offered for the second year and has proved to be one of the most desirable courses in our present curriculum, particularly for students interested along marketing lines. The courses offered during the past year and the number of students attending each are noted in the following table:

Class.	Subject.	Number course.	Hours per week.	Number students enrolled.
Fall term:				
Sophomore agriculture..	Fruit growing	2	4	159
Junior agriculture	Pomology	4	7	22
Senior agriculture	Advanced pomology	11a	7	20
Senior agriculture	Advanced landscape gardening	12a	5	7
Junior and senior, H. E..	Landscape gardening and floricult're.	14	7	27
Senior agriculture	Geography of horticulture	15	5	21
Senior agriculture	Landscape gardening practice	17a	10	7
Winter term:				
Sophomore agriculture..	Plant propagation	3	4	130
Junior agriculture	Greenhouse industry	5	7	22
Senior agriculture	Advanced pomology	11b	7	21
Senior agriculture	Advanced landscape gardening	12b	5	6
Senior agriculture	Commercial horticulture	16	5	21
Senior agriculture	Landscape gardening practice	17b	10	6
Spring term:				
Junior agriculture	Landscape gardening	6	7	23
Senior agriculture	Plant breeding	7	7	20
Senior agriculture	Advanced pomology	11c	7	20
Senior agriculture	Advanced landscape gardening	12c	5	6
Junior and senior, H. E..	Plant propagation and veg. gard'n'g.	13	7	0
Seniors	Landscape gardening practice	17c	10	6

In addition to these regular courses, instruction was given during the summer school as in previous years. During the winter term Mr. Stanley Johnston, in charge of the South Haven Experiment Station, took charge of our short courses and we are pleased to report that his services were very efficient, and we believe this new arrangement of having our Superintendent from the South Haven Station devote his energies to teaching during the winter term, will prove a very satisfactory one, both to the department and to the students of the short courses. This will prevent the necessity of engaging inexperienced and new instructors each year for short course teaching work.

We have also continued the work of teaching the Federal Aid students; some of these students joining our regular classes, but most of them being handled in separate classes and most of the instruction being given to them in the form of laboratory work.

A number of important changes have been made in the courses of study in horticulture for the coming year. The fundamental purpose of these changes was to make many of the courses offered by this department during the junior and senior years available for other agricultural students, and to enable the students in horticulture to elect work in the other technical departments of the division that is desirable in preparing them for a special field of service. Some courses in Soils, Commercial Fertilizers, and Farm Management, offered during the junior and senior years, seem as important to the horticultural student interested in fruit production as to the student specializing in farm crops or animal industry. These changes, therefore, that have been made in this department together with the changes made by the other technical departments of this division, will enable students to gain a more general agricultural training in preparation for high school agricultural teaching or county agent work, as well as to permit a greater intensification of the courses for those desiring stronger specialization. This increased flexibility of the Agricultural and Horticultural departments we believe to be very desirable.

The Horticultural department is still handicapped by the lack of proper facilities in offering instructional work, and we feel that these facilities must be provided very shortly if this department is to maintain its enviable position throughout the country for the efficiency of its horticultural teaching work and the success of its graduates. The past year the inefficiency of our cold storage plant made it difficult for us to provide the proper supply of fruits for classroom study, and also for storing fruit for exhibition purposes. Our cold storage system has gone to pieces and the building itself is in such poor condition that it does not seem feasible to expend the money required to repair our cold storage system. In view of the fact that the department has reason to expect a new horticultural building within the next few years, when it is planned to have a cold storage as a part of the building, it seems necessary to get along as best we can until this time arrives. We are handicapped also for proper laboratories to teach work along horticultural products lines, and proper greenhouse facilities for teaching work in vegetable gardening and floriculture.

While these matters have been called to your attention in previous reports, I wish to emphasize the fact that as time goes on the needs become even more pressing, and therefore I must repeat the importance of providing these facilities if the success and development of this department is to be secured.

It is a pleasure to report that the work of Associate Professor R. E. Marshall; Assistant Professors Thomas Gunson, R. E. Loree and N. L. Partridge; Extension Specialists, H. C. Moore and T. A. Farrand; and Miss Mary Rozema has, as in the past, proved very efficient. The writer wishes to express his appreciation for their support and cooperation in the work of the department.

Very respectfully submitted,

C. P. HALLIGAN.

Professor of Horticulture.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF FARM MANAGEMENT.

President F. S. Kedzie,
East Lansing, Michigan.

Dear President Kedzie:

During the year the Farm Management department was organized and certain courses where taken over from other departments. Agriculture 2 given in the Dean's department and Agricultural Economics 3a given in the Economics department were combined, and given under two courses in the new department. One of these courses taking up the question of farm organization and farm accounts, and the other course has for its objective the study of such other business problems as farm contracts, farm credits, insurance and other related subjects.

One course in Marketing was also taken over. It deals with the general theory of marketing as applied to and effecting farm management problems.

A new group of studies in the short course was also arranged for and is called the Farm Business Course. In this course the following subjects are given: farm management, farm accounts, rural credit, agricultural arithmetic, farm insurance and farm business problems.

Very truly yours,
H. M. ELIOT,
Professor of Farm Management.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF POULTRY HUSBANDRY.

To the President:
Dear Sir:

I have the honor to submit the following report of the Department of Poultry Husbandry for the year ending June 30, 1921.

BUILDINGS.

At present we are making use of twenty-four buildings for poultry work. One house 18 ft. by 184 ft., one house 16 ft. by 84 ft. with two stories and basement, three houses each 16 ft. by 24 ft., three colony houses each 6 ft. by 8 ft., ten portable colony houses each 10 ft. by 12 ft., one house 20 ft. by 20 ft., one house 14ft. by 28 ft., one house 10 ft. by 14 ft., one house 12 ft. by 24 ft., and one house 20 ft. by 80 ft. with basement and one house 18 ft. by 20 ft.

Our laying quarters cover 6,182 square feet of floor space and will accommodate 1,550 hens. We have 1,484 square feet of brooder space that will accommodate 5,000 chicks.

EQUIPMENT.

The department has operated twenty-five incubators during the year. Both the hot water and hot air types are to be found in our laboratories.

A coal stove brooder system is in full use in the poultry plant. There are nearly 3,500 chicks upon range (June 6).

Upwards of 800 head of fowls have been kept for commercial, educational, and investigational purposes. The leading breeds that have been kept for investigational and breeding purposes are as follows: Barred Rocks, 163; White Leghorns, 496; and Rhode Island Reds, 53. The following breeds have been kept for demonstration purposes: White Wyandottes, 13; Buff Orphingtons, 14; Brown Leghorns, 25; Miscellaneous, 46.

Ducks: 5 Pekin, 23 Muscovy (Colored) and Muscovy (White), 5 Mallard.

Geese: 5 Toulouse, 2 Emden.

Pigeons: Ten pairs of White Kings are being bred in order that information can be given to the State upon the possibilities of squab raising for market purposes.

Turkeys: One pen (1 male, 4 females and 11 young) is being bred by J. W. Hemans, Onondaga, for the College upon virgin soil.

EDUCATIONAL.

Poultry has been taught to college students during the entire year. Federal Aid men (40 in number) have been taught for two hours daily for twelve weeks.

Two short courses have been conducted during the year with good success by way of numbers, and I believe followed with interest among our students. A breed test of laying ability was started on November 1, 1920 and will close on the evening of October 31, 1921. There are twenty-four pens in the contest, each containing five hens. These were selected from flocks found in sixteen counties.

The 116 hens are trapped daily. Reports are mailed to each farmer whose hens are in the contest, every Monday morning, along with descriptions of methods of feeding and management. Monthly reports are sent to Agricultural and Poultry Journals for publication. Great interest is taken not only in the weekly reports but the monthly ones as well.

From November 1, 1920 to the evening of May 28, 1921 (thirty weeks) 116 hens (four having died) have laid 12,070 eggs, all of which have been sold for market purposes.

Amount received	$582.90
Amount paid for feed	181.10
Profit, or Labor Income	$401.80

Average per hen $3.46 for the first thirty weeks.

During the year a fine building 20 ft. by 80 ft. has been added to the department. This building will provide classrooms and laboratories, and will fill a long time need.

The laboratories are being equipped for next year's work and when complete will afford opportunity for doing a much higher class of work which will strengthen both classroom and research work for the College.

Respectfully submitted,
C. H. BURGESS,
Professor of Poultry Husbandry.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE SOILS DEPARTMENT.

President Kedzie:

Two new courses are being outlined, the one on commercial fertilizers required of all junior agricultural students, and the other on muck soils to be offered to seniors. It has been deemed advisable to introduce these courses because of the rapidly growing use of commercial fertilizers in the State, and the agricultural future of muck lands. In order that these and other courses offered by the members of the department may be satisfactorily presented, greenhouse space is imperative.

Certain members of the staff are desirous of attending other institutions to undertake graduate work. This attitude certainly is commendable and if done should strengthen the organization. I trust that the administration will see fit to make it possible for this to be brought about.

The results obtained from the various lines of endeavor are on the whole, gratifying. We are able to meet only a relatively small per cent of the requests for the inauguration of experimental and demonstrational projects on soils, and for information derived from such. Especially is this the case where the lighter soils of the State are concerned—consequently we are in need of an assistant to act as leader in this work.

The members of the staff again desire you to know that your interest in the various projects and your timely suggestions are appreciated.

Respectfully yours,
M. M. McCOOL,
Professor of Soils.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEAN OF ENGINEERING.

Dr. F. S. Kedzie, President,
Michigan Agricultural College.
Dear Sir:

I have the honor to present my fourteenth annual report as Dean of Engineering.

Personnel.

Civil Engineering.

H. K. Vedder, Professor,
C. L. Allen, Associate Professor,
C. M. Cade, Assistant Professor,
R. G. Saxton, Assistant Professor,
W. W. Hitchcock, Assistant Professor,
B. K. Philp, Assistant Professor,
F. A. Gould, Instructor,
J. F. Gibbs, Instructor,

Drawing and Design.

R. K. Steward, Professor,
C. Newman, Associate Professor,
L. N. Field, Associate Professor,
A. G. Scheele, Associate Professor,
Miss C. Holt, Assistant Professor,
J. W. Steward, Assistant Professor,
J. E. Robertson, Assistant Professor,
E. H. Stewart, Assistant Professor,
C. L. Brattin, Assistant Professor,
J. Rising, Instructor,
O. W. Fairbanks, Instructor,
M. B. Chapin, Instructor,
Miss E. Butler, Instructor,

Electrical Engineering.

A. R. Sawyer, Professor,
M. M. Cory, Associate Professor,
L. S. Foltz, Associate Professor,
E. E. Kinney, Instructor,
R. D. Wyckoff, Instructor,

Mechanical Engineering.

H. B. Dirks, Professor,
W. E. Reuling, Assistant Professor,
G. C. Wright, Assistant Professor,
V. W. Hewlett, Assistant Professor,
P. J. Baker, Assistant Professor,
A. P. Krentel, Instructor,
A. Watt, Instructor,
J. A. Eicher, Instructor,
G. J. Posthumus, Instructor,
D. T. Millard, Instructor,
W. L. Watt, Instructor,
C. N. Rix, Instructor,
E. C. Crawford, Assistant.

Changes in Personnel During the Year.

Mr. Andrew Watt died during the spring vacation after a brief illness. Mr. Watt served the College faithfully and well as instructor in forging and horseshoeing in the Farm Mechanics department from 1909 to 1916, and thereafter as instructor in forging in the Mechanical Engineering department. He had the respect and friendship of all college people during the years of his connection.

Mr. Watt was succeeded by Mr. Bert Sangster, transferred from the Farm Mechanics department.

Enrollment.

Official figures for 1920-21.

	Chem. E.	C. E.	E. E.	M. E.	Total.
Senior	5	27	15	21	68
Junior	10	28	20	26	84
Sophomore	24	29	49	44	146
Freshmen	28	65	59	56	208
Totals	67	149	143	147	506

The fluctuation in total enrollment and graduates in engineering for the past few years, including the war period, is shown by the following:

1915-16	Total	407	Graduates	66
1916-17		380		65
1917-18		300		34
1918-19		245		20
1919-20		460		48
1920-21		506		65

The total enrollment of 1919-20 and of 1920-21 is in excess of any previous figures, the previous peak having been reached 1912-13 with a total of 450.

Courses of Study.

The catalog, now in press, presents a few changes, suggested and enacted as a consequence of experience with the new courses inaugurated in 1918-19, and fully effective during the past year, viz:

Senior Year. Spanish, History and advanced Military Science have been added to and French dropped from the optional group of 3 credits per term for three terms.

Freshman Year. Chemistry increased from 4 to 5 credits in winter and spring terms. Drawing reduced from 5 to 4 credits in the winter and increased from 3 to 4 in the spring term. History and Political Science dropped from the spring term, and Current Events to alternate with English in the winter and spring terms.

In my opinion the courses are too heavy for effective work and should be reduced to 16 or 17 credit hours per term.

Equipment.

No notable additions to the material equipment of the departments have been made.

Short Courses.

Cooperating with the Farm Mechanics department the Mechanical Engineering department, in February and March, conducted two four-weeks' "Truck and Tractor" courses which were well attended.

Summer School.

The experience of the past few years indicates that the work in engineering subjects during the summer session is not taken by enough students to pay for the trouble and expense entailed.

Special Activities.

Home Builders' Conference. Jointly with the Farm Mechanics department, the Division of Engineering extended the facilities of the College to the Portland Cement Association, Jan. 13 and 14, 1921, for interesting and instructive lectures, discussions, and demonstrations relative to the use of cement and concrete in house building.

Lectures. Col. H. C. Boyden, U. S. A., addressed the Civil Engineering department, students and instructors, on the subject of "Cement and Concrete."

Mr. F. F. Burroughs, '09, General Manager of the Mutual Fire Prevention Bureau, Chicago, on Mar. 1, 1921, addressed engineering students and teachers on "Insurance Engineering" and two days later on "Fire Prevention Methods."

In addition the departments have benefited by impromptu talks by practical men in their respective fields of work. Many of these speakers are alumni of the College.

The student branches of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the American Chemical Society have met frequently.

Needs.

Besides the usual and reasonable requirements of the departments for new apparatus, I mention the subject of experiment station, and additional building space for certain features of the work, as worthy of serious consideration, and I am hoping that I may be called upon to present these needs in greater detail before very long.

Respectfully submitted.

G. W. BISSELL,
Dean of Engineering.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE CIVIL ENGINEERING DEPARTMENT.

President F. S. Kedzie,
College.

Dear Sir:

For this department the year just ended shows a very satisfactory record, whether measured by past experience or by immediate results. Student endeavor seems to have returned to normal zeal and purpose; the teaching staff has met its part of the college program with commendable efficiency.

The department teaching staff for the year included the names listed below in the order of seniority of appointment. There were no withdrawals during the year. To complete the record, it must be noted that in the fall term, Mr. R. O. Van Orden was engaged as student instructor in the field work of surveying for two hours per week.

H. K. Vedder, C. E., Professor of Civil Engineering
C. M. Cade, C. E., Assistant Professor of Civil Engineering
R. G. Saxton, C. E., Assistant Professor of Civil Engineering
W. W. Hitchcock, C. E., Assistant Professor of Civil Engineering
B. K. Philp, C. E., Assistant Professor of Civil Engineering
C. L. Allen, C. E., Associate Professor of Civil Engineering
J. F. Gibbs, B. S., Instructor in Civil Engineering
F. A. Gould, C. E., Instructor in Civil Engineering

The tabulation which follows will answer all questions with reference to the teaching schedule, the number of classes and the attendance therein.

CLASS WORK—CIVIL ENGINEERING DEPARTMENT FOR COLLEGE YEAR 1920–1921.

FALL TERM, 1921.

Class.	Subject.	No. of course.	Instructor.	No. hrs. per week.	Number students in class.
Sophomores	Surveying (class)	C. E. 1a.	Mr. Gibbs	2	25
Sophomores	Surveying (class)	C. E. 1a.	Prof. Philp	2	21
Sophomores	Surveying (class)	C. E. 1a.	Mr. Gould	2	21
Sophomores	Surveying (class)	C. E. 1a.	Mr. Gibbs	2	23
Sophomores	Surveying (class)	C. E. 1a.	Mr. Gould	2	21
Sophomores	Surveying (class)	C. E. 1a.	Mr. Gibbs	2	15
Sophomores	Surveying (field)	C. E. 1a.	Mr. Gould Mr. Gibbs	2	28
Sophomores	Surveying (field)	C. E. 1a.	Mr. Gould	2	19
Sophomores	Surveying (field)	C. E. 1a.	Prof. Philp Mr. Gould	2	22
Sophomores	Surveying (field)	C. E. 1a.	Mr. Gibbs Mr. Gibbs	2	22
Sophomores	Surveying (field)	C. E. 1a.	Prof. Saxton Mr. Gibbs	2	23
Sophomores	Surveying (class)	C. E. 1b.	Mr. Gibbs	2	19
Sophomores	Surveying (class)	C. E. 1b.	Mr. Gould	2	18
Sophomores	Surveying (field)	C. E. 1b.	Mr. Gibbs Prof. Saxton	4	18
Sophomores	Surveying (field)	C. E. 1b.	Prof. Hitchcock Mr. Van Orden	4	19
Juniors	Mechanics	C. E. 4a.	Prof. Allen	5	13
Juniors	Mechanics	C. E. 4a.	Prof. Allen	5	9
Juniors	Mechanics	C. E. 4a.	Prof. Philp	5	14
Juniors	Mechanics	C. E. 4a.	Prof. Hitchcock	5	12
Juniors	Mechanics	C. E. 4a.	Prof. Allen	5	11
Juniors	Mechanics	C. E. 4a.	Prof. Philp	5	8
Juniors	Adv. surveying (class)	C. E. 6a.	Prof. Cade	2	14
Juniors	Adv. surveying (class)	C. E. 6a.	Prof. Hitchcock	2	13
Juniors	Adv. surveying (field)	C. E. 6a.	Prof. Hitchcock Mr. Gould	4	13
Juniors	Adv. surveying (field)	C. E. 6a.	Prof. Cade Prof. Hitchcock	4	14
Seniors	Surveying methods (class)	C. E. 2.	Prof. Philp	3	9
Seniors	Surveying methods (field)	C. E. 2.	Prof. Philp	4	9
Seniors	Graphic statics (class)	C. E. 4d.	Prof. Allen	2	25
Seniors	Graphic statics (field)	C. E. 4d.	Prof. Allen Mr. Gibbs	4	25
Seniors	Hydraulics	C. E. 5.	Prof. Saxton	5	11
Seniors	Hydraulics	C. E. 5.	Prof. Saxton	5	17
Seniors	Hydraulic laboratory	C. E. 5.	Prof. Saxton	4	26
Seniors	Bridge stresses	C. E. 8a.	Prof. Vedder	3	15
Seniors	Bridge stresses	C. E. 8a.	Prof. Vedder	3	14
Total				109	599

CLASS WORK—CIVIL ENGINEERING DEPARTMENT FOR COLLEGE YEAR 1920-1921.

WINTER TERM, 1921.

Class.	Subject.	No. of course.	Instructor.	No. hrs. per week.	Number students in class.
Sophomores	Sand, cement and concrete (class)	C. E. 16a.	Prof. Allen	2	23
Sophomores	Sand, cement and concrete (class)	C. E. 16a.	Prof. Hitchcock	2	15
Sophomores	Sand, cement and concrete (field)	C. E. 16a.	Prof. Allen Prof. Hitchcock	4	12
Sophomores	Sand, cement and concrete (field)	C. E. 16a.	Prof. Allen Prof. Hitchcock	4	26
Seniors, Juniors	Agricultural engineering	C. E. 3a.	Prof. Cade	3	26
Juniors	Mechanics	C. E. 4b.	Prof. Philp	5	11
Juniors	Mechanics	C. E. 4b.	Mr. Gibbs	5	9
Juniors	Mechanics	C. E. 4b.	Prof. Gould	5	9
Juniors	Mechanics	C. E. 4b.	Prof. Hitchcock	5	15
Juniors	Mechanics	C. E. 4b.	Prof. Philp	5	12
Juniors	Mechanics	C. E. 4b.	Mr. Gibbs	5	8
Juniors	Mechanics	C. E. 4b.	Prof. Philp	5	13
Juniors	Sewerage (class)	C. E. 19.	Prof. Gould	3	15
Juniors	Sewerage (class)	C. E. 19.	Prof. Gould	3	12
Juniors	Topographic mapping (lab.)	C. E. 7a.	Prof. Cade Prof. Gould	6	29
Seniors	Bridge analysis and design (lab.)	C. E. 8b.	Prof. Vedder Prof. Philp	8	26
Seniors	Masonry and arches (class)	C. E. 9a.	Prof. Allen	2	11
Seniors	Masonry and arches (class)	C. E. 9a.	Prof. Allen	2	15
Seniors	Masonry and arches (lab.)	C. E. 9a.	Mr. Gibbs Prof. Allen	4	11
Seniors	Masonry and arches (lab.)	C. E. 9a.	Mr. Gibbs Prof. Allen	4	14
Seniors	Pavements (class)	C. E. 10.	Prof. Saxton	2	11
Seniors	Pavements (class)	C. E. 10.	Prof. Saxton	2	15
Seniors	Water supply	C. E. 15a.	Prof. Cade	5	10
Seniors	Water supply	C. E. 15a.	Prof. Saxton	5	13
Seniors	State highway construction	C. E. 20a.	Prof. Saxton	3	11
Seniors	Highway law	C. E. 20b.	Prof. Saxton	2	4
Total				101	376

CLASS WORK—CIVIL ENGINEERING DEPARTMENT FOR COLLEGE YEAR 1920-1921.

SPRING TERM, 1921.

Class.	Subject.	No. of course.	Instructor.	No. hrs. per week.	Number students in class.
Sophomores	Surveying and leveling (class)	C. E. 1c.	Prof. Cade	3	12
Sophomores	Surveying and leveling (class)	C. E. 1c.	Prof. Hitchcock	3	19
Sophomores	Surveying and leveling (class)	C. E. 1c.	Mr. Gould	3	17
Sophomores	Surveying and leveling (class)	C. E. 1c.	Mr. Gibbs	3	20
Sophomores	Surveying and leveling (class)	C. E. 1c.	Mr. Gould	3	14
Sophomores	Surveying and leveling (class)	C. E. 1c.	Prof. Cade	3	16
Sophomores	Surveying and leveling (field)	C. E. 1c.	Mr. Gibbs	4	14
Sophomores	Surveying and leveling (field)	C. E. 1c.	Mr. Gibbs	4	18
Sophomores	Surveying and leveling (field)	C. E. 1c.	Prof. Allen Prof. Hitchcock	4	20
Sophomores	Surveying and leveling (field)	C. E. 1c.	Mr. Gould Prof. Philp	4	18
Sophomores	Surveying and leveling (field)	C. E. 1c.	Prof. Hitchcock Mr. Gould	4	28
Sophomores	Surveying methods (class)	C. E. 2a.	Prof. Cade	3	21
Sophomores	Surveying methods (field)	C. E. 2a.	Prof. Cade	4	21
Sophomores	Adv. surveying (class)	C. E. 6.	Mr. Gibbs	3	18
Sophomores	Adv. surveying (class)	C. E. 6.	Prof. Philp	3	13
Sophomores	Adv. surveying (field)	C. E. 6.	Prof. Cade Mr. Gibbs	4	19
Sophomores	Adv. surveying (field)	C. E. 6.	Prof. Saxton Prof. Philp	4	12
Juniors	Strength of materials	C. E. 4c.	Prof. Philp	5	11
Juniors	Strength of materials	C. E. 4c.	Prof. Allen	5	11
Juniors	Strength of materials	C. E. 4c.	Prof. Philp	5	13
Juniors	Strength of materials	C. E. 4c.	Prof. Gould	5	11
Juniors	Strength of materials	C. E. 4c.	Prof. Hitchcock	5	13
Juniors	Strength of materials	C. E. 4c.	Prof. Philp	5	9
Juniors	Strength of materials	C. E. 4c.	Mr. Gibbs	5	7
Juniors	Railroad surveying (class)	C. E. 7.	Prof. Saxton	3	11
Juniors	Railroad surveying (class)	C. E. 7.	Prof. Cade	3	10
Juniors	Railroad surveying (field)	C. E. 7.	Prof. Saxton Prof. Cade	4	10
Juniors	Railroad surveying (field)	C. E. 7.	Prof. Saxton	4	11
Juniors	Astronomy (class)	C. E. 14.	Prof. Vedder	2	12
Juniors	Astronomy (class)	C. E. 14.	Prof. Vedder	2	14
Juniors	Astronomy (field)	C. E. 14.	Prof. Vedder Prof. Philp	2	12
Juniors	Astronomy (field)	C. E. 14.	Prof. Vedder Prof. Philp	2	14
Juniors	Reinforced concrete (class)	C. E. 16b.	Prof. Allen	3	13
Juniors	Reinforced concrete (class)	C. E. 16b.	Prof. Hitchcock	3	10
Juniors	Reinforced concrete (field)	C. E. 16b.	Prof. Allen Prof. Hitchcock	4	10
Juniors	Reinforced concrete (field)	C. E. 16b.	Prof. Allen Prof. Hitchcock	4	13
Juniors, Seniors	Road construction (class)	C. E. 17.	Prof. Saxton	2	5
Juniors, Seniors	Road construction (field)	C. E. 17.	Prof. Saxton	6	5
Seniors	Thesis	C. E. 11.	Prof. Vedder Prof. Allen	20	22
Seniors	Contracts and specifications	C. E. 13.	Prof. Vedder	3	43
Seniors	Contracts and specifications	C. E. 13.	Prof. Vedder	3	22
Total				164	612

The following text-books have been used in our classes during the year: Merriman & Jacoby's Roofs & Bridges, Vols. I & III; Malcolm's Graphic Statics; Poorman's Mechanics; Russell's Hydraulics; Hool & Johnson's Concrete Engineers' Handbook; Blanchard's American Highway Engineers Handbook; Harger & Bonney's Highway Engineers' Handbook; Turneaure & Russell's Public Water Supplies; Metcalf & Eddy's American Sewerage Practice, Vol. I; Hosmer's Astronomy; Boyd's Strength of Materials; Allen's Railroad Curves & Earthwork (with tables); Breed & Hosmer's Surveying, Vols. I & II; Elliott's Engineering For Land Drainage, and Tucker's Contracts in Engineering.

The total expenditure by the department during the year for all purposes except salaries has been $1,628.06. During the same period the sum of $535.00 has been turned in for class and examination fees. Our annual inventory for 1921 shows an aggregate of $19,138.95 as against $17,965.73 in 1920.

Respectfully submitted,
H. K. VEDDER,
Professor of Civil Engineering.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF ELECTRICAL ENGINEERING.

President F. S. Kedzie,
Michigan Agricultural College,
East Lansing, Michigan.

Dear Sir:

I have the honor to submit the following report upon the Department of Electrical Engineering, for the year ending June 30, 1921.

TEACHING STAFF FOR THE YEAR.

The teaching staff for the department was as follows:

A. R. Sawyer, Professor.
M. M. Cory, Associate Professor.
L. S. Foltz, Associate Professor.
E. E. Kinney, Instructor.
R. D. Wyckoff, Special Research Instructor.

Professor Foltz was head of the Department of Electrical Engineering at the Colorado Agricultural College, and has given his attention particularly to the work of the seniors in Alternating Currents. Mr. E. E. Kinney, who graduated with the class of 1915 and came to us after several years of experience in the commercial field, has carried the work in Electrical Measurement, Storage Batteries, and the D. C. Laboratory. Mr. Wyckoff, who graduated last year, came to do some experimental work in Wireless Telegraph and Telephony. These three men have added to the capacity of the department very considerably and made it possible for us to accomplish more than in previous years.

The application of electrical principles to industrial work has been so broad that it is impossible for one or two men to adequately cover the field.

The department planned to establish a wireless telephone station, in order to cooperate with the local weather bureau, in giving, by wireless telephone, various reports to the farmers of the State directly. We had very little to start with and considerable apparatus has been made, while some difficulty was encountered in getting everything ready because of the novelty of the idea. The Department of Agriculture at Washington is now trying out the same idea in sending crop reports, prices, weather reports, time, etc., broadcast. We shall endeavor to take this information and send it out by wireless telephone to the people of the State.

Accompanying is a class report for the past year.

FALL TERM 1920.

E. E. 1a—Elec. of E. E.—Juniors in E. E.—6 hours of Computation—20 students—Mr. Cory.

E. E. 30—Storage Batteries—Juniors and Seniors—Electricals—2 hours rec.—2 hours of Lab.—36 students—Mr. Kinney.

E. E. 35—Electro Chemistry—Senior—Electricals and Chemicals—3 hours rec.—4 hours Lab.—14 students—Mr. Sawyer and Mr. Ewing.

E. E. 14—Electro Measurements—Juniors in E. E.—2 hours Rec. 4 hours Lab.—23 students—Mr. Sawyer and Mr. Kinney.

E. E. 14a—Electro Measurements—Juniors in M. E.—2 hours Rec.—2 hours Lab.—23 students—Mr. Sawyer and Mr. Kinney.

E. E. 3a—Alternating Current—Seniors in E. E.—5 hours Rec.—2 hours Lab.—16 students—Mr. Foltz and Mr. Cory.

E. E. 20—Power Transmission—Seniors in E. E.—3 hours Rec.—17 students—Mr. Foltz.

E. E. 6a—D. C. Machines—Junior Civils and Chemicals—3 hours Rec.—43 students—Mr. Cory.

E. E. 18c—Alternating Current—Seniors in M. E.—2 hours Rec.—4 hours of Lab.—21 students—Mr. Foltz.

WINTER TERM 1920.

E. E. 1b—Dynamo Electric Machinery—Juniors in E. E.—5 hours Rec.—19 men—Mr. Sawyer.

E. E. 14b—Electro Measurements—Juniors in E. E.—2 Rec.—2 hours Lab.—19 students—Mr. Sawyer and Mr. Kinney.

E. E. 18a—Dynamo Electric Machinery—Juniors in M. E.—4 hours Rec.—21 students—Mr. Sawyer.

E. E. 3b—A. C. Machines—Seniors in E. E.—5 hours Rec.—18 students—Mr. Foltz.

E. E. 4—A. C. Lab.—Seniors in E. E.—10 Lab. hours—18 students—Mr. Cory

E. E. 10—A. C. Design—Seniors in E. E.—6 hours Lab.—6 students—Mr. Foltz.

E. E. 12—Elec. Illumination—Seniors in E. E.—2 recitations per week—13 students—Mr. Foltz.

E. E. 15—Electro Measurements—Seniors in E. E.—2 Rec. and 2 Lab. hours—11 students—Mr. Wyckoff.

E. E. 21—Power Distribution—Seniors in E. E.—4 Lab. hours—13 students—Mr. Cory.

E. E. 25—Communication—1 Rec. 2 hours Lab.—13 students—Mr. Wyckoff.

E. E. 6b—Alternating Current Machines—3 hours Rec.—4 Lab. hours—43 students—Mr. Cory and Mr. Kinney.

SPRING TERM 1921.

E. E. 1c—D. C. Design—5 Rec. hours—18 students—Mr. Sawyer.
E. E. 2—D. C. Lab.—Juniors in E. E.—4 Lab. hours—18 students—Mr. Kinney.
E. E. 18b—Auto. Electrics—Juniors in M. E.—3 Rec.—4 hours Lab.—22 students—Mr. Kinney.
E. E. 22—Electrical Railways—Seniors in E. E.—4 Lab. hours—13 students—Mr. Cory.
E. E. 26—Electric Communication—1 Rec. hour—2 hours Lab.—10 students—Mr. Wyckoff.
E. E. 28—Hydro—Electric Power Development—Seniors in E. E.—4 hours Lab.—15 students—Mr. Foltz.

Respectfully submitted,
A. R. SAWYER,
Professor of Electrical Engineering.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

Dr. F. S. Kedzie, President.
Michigan Agricultural College.
East Lansing, Mich.

Dear Sir:

The following is a report of the work of the Department of Mechanical Engineering for the year ending June 30th, 1921.

The personnel of the department at the end of the year was as follows:

H. B. Dirks, Professor of Mechanical Engineering.
W. E. Reuling, Assistant Professor of Mechanical Engineering.
G. C. Wright, Assistant Professor of Mechanical Engineering.
V. W. Hewlett, Assistant Professor of Mechanical Engineering.
P. J. Baker, Metallurgical Engineer.
A. P. Krentel, Foreman of Wood Shop.
G. J. Posthumus, Instructor in Wood Shop.
D. T. Millard, Instructor in Wood Shop.
W. L. Watt, Instructor in Machine Shop.
C. N. Rix, Instructor in Machine Shop.
J. A. Eicher, Instructor in Foundry.
B. Sangster, Instructor in Forge Shop.
E. C. Crawford, Laboratory Engineer.
Ray Pearson, Storekeeper.
J. F. Hineline, Machinist.
Miss J. B. Allan, Stenographer.

You will note that there have been several changes in personnel since last year. The resignation of Mr. W. G. Hildorf was probably our greatest loss, and coming as it did so late in the summer created an unfortunate condition. However, with the appointment of Mr. P. J. Baker, of the class of 1908, we

were able to continue the work in the Metallurgical courses formerly carried by Mr. Hildorf.

In order to take care of the new optional courses in the senior year, Mr. V. W. Hewlett was appointed to take charge of the courses in Automotive Engineering. Before coming to M. A. C., Mr. Hewlett had charge of automotive courses at Pennsylvania State College.

The death of Mr. Andrew Watt on March 14th, following an operation took from our teaching staff another member whose work was always well done, and whose personality was such as to make his loss very noticeable. Mr. B. Sangster, formerly tool-room attendant in the Farm Mechanics department, however, has proved an able successor to Mr. Watt, and the work of the forge shop is being well taken care of, especially so, as Mr. Sangster has had experience both in agricultural and engineering work.

As in the past two years, assistance was again given the Farm Mechanics department in the teaching of several courses in the Truck and Tractor short course. Instruction was given in Forge Shop and the equipment of the department was used in the course in Ignition and Lighting, Truck Engines and Carburetion.

In the summer school courses were offered in the Wood Shop, Forge Shop and Machine Shop, but with the exception of a week's instruction to Manual Training teachers in the Wood Shop, the Machine Shop courses were the only ones in which students were enrolled. Here thirteen students were registered in three courses.

The principal new equipment obtained during the year consists of two electric motors, which have been placed in the machine shop to drive some of the government machine tools, purchased last year. In order to make use of all the machine tools purchased it will be necessary to acquire several more motors. In addition to the above motor requirements, we are in particular need of another Universal testing machine in the materials testing laboratory, dynamometers for testing automotive equipment, and a switch board for the Turbo-Generator. The latter is necessary not only for a proper installation, but also for emergency use in furnishing current to the College in case of a breakdown in the College Power House.

The optional courses of the senior year, which were given for the first time, were divided among the 23 seniors as follows: Automotive Engineering, 7 men; Steam Engineering, 2 men; Industrial Engineering, 14 men. Several of the men, however, having advance credits, took courses in more than one group. The Industrial and Automotive groups are closely allied, and the fact that most of the seniors chose these groups was no doubt due to the position which the State holds in these lines and therefore of the probable demand there would be for men who had specialized along these lines.

I wish to express my appreciation of the work of the various members of the department, during the past year and wish especially to acknowledge the work of Mr. Wright in organizing the new courses in Industrial Engineering.

The teaching schedule for the year is shown in the tables that follow:

TABLE 1.—CLASS WORK OF DEPARTMENT OF MECHANICAL ENGINEERING—FALL TERM, 1920.

Class.	Subject.	No. of course.	Teacher.	Hrs. per week each student.	No. of students.	Student hrs. per week.
Freshman	Elements of engineering	1	Dean Bissell	1	189	189
Freshman	Wood shop	2d	Mr. Krentel, Mr. Posthumus	4	99	396
Freshman	Forge shop	3d	Mr. Watt	4	101	404
Junior	Steam engines	7a	Mr. Dirks, Mr. Hewlett	3	56	168
Senior	Boilers and stokers	7c	Mr. Dirks	3	4	12
Juniors	Engineering laboratory	13a	Mr. Reuling, Mr. Hewlett	4	82	328
Seniors	Engineering laboratory	13d	Mr. Reuling	8	23	184
Freshman	Wood shop	31	Mr. Krentel, Mr. Millard	5	130	650
Sophomore	Forge shop	41	Mr. Watt	4	86	344
Senior	Heat treatment	43	Mr. Baker	5	24	120
Sophomore	Foundry	51	Mr. Eicher	4	91	364
Freshman	Machine shop	61	Mr. Wright, Mr. Rix	5	69	345
Junior	Machine shop	62	Mr. Wright, Mr. Watt	5	20	100
Junior	Machine shop	63	Mr. Watt	5	2	10
Junior	Seminar	71a	Mr. Dirks	2	25	50
Senior	Seminar	72a	Mr. Dirks	2	23	46
Total					1,054	3,710

TABLE 2.—CLASS WORK OF DEPARTMENT OF MECHANICAL ENGINEERING—WINTER TERM, 1920.

Class.	Subject.	No. of course.	Teacher.	Hrs. per week each student.	No. of students.	Student hrs. per week.
Senior	Industrial management	5a	Mr. Wright	7	14	98
Junior	Gas engine	7b	Mr. Hewlett	2	56	112
Junior	Metallurgy	11a	Mr. Baker	2	29	58
Senior	Timber physics	11b	Mr. Reuling	5	5	25
Junior	Engineering laboratory	13b	Mr. Reuling	4	70	280
Senior	Ind. combustion engines	17c	Mr. Hewlett	7	8	56
Senior	Heating and ventilation	18a	Mr. Dirks	3	22	66
Senior	Power station design	18b	Mr. Dirks	7	5	35
Senior	Costs, accounting, etc.	18c	Dean Bissell	3	70	210
Freshman	Wood shop	31	Mr. Krentel, Mr. Posthumus	5	47	235
Freshman	Wood shop	32	Mr. Millard	5	70	350
Sophmore	Forge shop	42	Mr. Baker	6	43	258
Sophmore	Foundry	52	Mr. Baker, Mr. Eicher	6	51	306
Freshman	Machine shop	61	Mr. Wright, Mr. Rix	5	56	280
Junior	Machine shop	62	Mr. Wright, Mr. Watt	5	5	25
Junior	Machine shop	63	Mr. Wright, Mr. Watt	5	20	100
Junior	Seminar	71b	Mr. Dirks	2	23	46
Senior	Seminar	72b	Mr. Dirks	2	24	48
Total					578	2,588

TABLE 3.—CLASS WORK OF DEPARTMENT OF MECHANICAL ENGINEERING—SPRING TERM, 1921.

Class.	Subject.	No. of course.	Teacher.	Hrs. per week each student.	No. of students.	Student hrs. per week.
Freshman....	Wood shop..................	2d	Mr. Krentel, Mr. Posthumus..	4	75	300
Freshman....	Forge shop..................	3d	Mr. Sangster...............	4	66	264
Senior.......	Factory design..............	5b	Mr. Wright.................	7	14	98
Junior.......	Engineering laboratory.......	13c	Mr. Reuling................	4	66	264
Junior.......	Thermodynamics.............	17a	Mr. Dirks..................	4	50	200
Senior.......	Automotive design...........	17d	Mr. Hewlett................	7	7	49
Senior.......	Technical problems..........	19a	Mr. Dirks, Mr. Wright, Mr. Baker, Mr. Hewlett	16	23	368
Freshman....	Wood shop..................	32	Mr. Krentel, Mr. Millard.....	5	89	445
Sophomore..	Forge shop..................	42	Mr. Baker..................	6	42	252
Sophomore..	Foundry....................	52	Mr. Baker, Mr. Eicher.......	6	30	180
Freshman....	Machine shop...............	61	Mr. Wright, Mr. Rix.........	5	57	285
Junior.......	Machine shop...............	62a	Mr. Wright, Mr. Watt.......	4	20	80
Junior.......	Seminar....................	71c	Mr. Dirks..................	2	22	44
Senior.......	Seminar....................	72c	Mr. Dirks..................	2	23	46
Total...	....	....	....	....	584	2,875

Respectfully submitted,
H. B. DIRKS,
Professor of Mechanical Engineering.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF DRAWING.

President F. S. Kedzie,
East Lansing, Michigan.

Dear Sir:

I herewith present to you my fifth annual report as head of the Department of Drawing and Design for the year ending June 30, 1921.

The personnel of the department at the opening of the college year was as follows:

R. K. Steward, C.E., Professor.
Chace Newman, Associate Professor.
L. N. Field, B.M.E., Associate professor.
A. G. Scheele, A.M., Associate professor.
Miss C. L. Holt, Assistant professor.
J. W. Steward, B.M.E., Assistant professor.
E. H. Stewart, B.S. in M.E., Assistant professor.
C. L. Brattin, B.M.E., Assistant professor.
M. B. Chapin, Ph.B., Instructor.
J. Rising, M.E., Instructor.
Miss Edith Butler, Instructor.
O. W. Fairbanks, B.S., Instructor.
J. E. Robertson, B.S., C.E., Instructor.

This year has been one in which we have had an opportunity to work with smaller sections and I feel that as a result of this fact, a higher standard has been set. There has also been more time to devote to the designing and planning of the different courses taught in the department, and outlines and specifications are now complete for all courses to be taught next year. In addition to this work, the different instructors have put in over 500 hours in the blue printing room in preparation for work next year, and have also been doing printing for other departments.

Last year for the first time in a number of years, the sophomore engineers were required to take a course of 4 hours per week in freehand drawing. They did this reluctantly, but this year's class is taking up the work in a different spirit and the results are very gratifying.

I wish to take this opportunity to again express my appreciation for the unanimous support which has been given me during the past year by the members of the department staff.

The following is a teaching schedule of the department:

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN—FALL TERM, 1920.

Class.	Subject.	No.	Instructor.	Hours.	No of students.
Freshmen	Mechanical drawing	4ab-1	Mr. Rising	6	20
Freshmen	Mechanical drawing	4ab-2	Mr. Fairbanks	6	16
Freshmen	Mechanical drawing	4ab-3	Mr. Brattin	6	15
Freshmen	Mechanical drawing	4ab-4	Mr. Brattin	6	24
Freshmen	Mechanical drawing	4ab-5	Mr. Fairbanks	6	18
Freshmen	Mechanical drawing	4ab-6	J. W. Steward	6	22
Freshmen	Mechanical drawing	4ab-7	Mr. Rising	6	18
Freshmen	Mechanical drawing	4ab-8	Mr. Stewart	6	14
Freshmen	Mechanical drawing	4ab-9	J. W. Steward	6	17
Freshmen	Mechanical drawing	4ab-10	Mr. Stewart	6	22
Freshmen	Mechanical drawing	4ab-11	Mr. Rising	6	21
Freshmen	Freehand drawing	1b-1	Mr. Chapin	6	18
Freshmen	Freehand drawing	1b-2	Miss Butler	6	20
Freshmen	Freehand darwing	1b-3	Miss Butler	6	20
Freshmen	Freehand drawing	1b-4	Mr. Chapin	6	18
Freshmen	Freehand drawing	1b-5	Mr. Chapin	6	20
Freshmen	Freehand drawing	1b-6	Miss Holt	6	15
Freshmen	Freehand drawing	1b-7	Miss Butler	6	18
Freshmen	Freehand drawing	1b-8	Mr. Chapin	6	19
Sophomores	Descrip. geometry	5a-1	Mr. Brattin, R. K. Steward	6	15
Sophomores	Descrip. geometry	5a-2	Mr. Fairbanks, Mr. Field	6	17
Sophomores	Descrip. geometry	5a-3	Mr. Robertson	6	22
Sophomores	Descrip. geometry	5a-4	Mr. Brattin, Mr. Field	6	17
Sophomores	Descrip. geometry	5a-5	Mr. Robertson	6	21
Sophomores	Descrip. geometry	5a-6	Mr. Stewart	6	13
Sophomores	Descrip. geometry	5a-7	Mr. Robertson, Mr. Field	6	19
Sophomores	Descrip. geometry	5a-8	Mr. Stewart	6	17
Sophomores	Drawing and color	1m	Mr. Scheele	10	10
Juniors	Shades and shadows	7-2a	Mr. Robertson	6	16
Juniors	Shades and shadows	7-2b	Mr. Rising	6	14
Juniors, Seniors	Mechanical drawing	3b	J. W. Steward	6	12
Juniors	Kinematics	6c-4a	Mr. Field	4	13
Juniors	Kinematics	6c-4b	Mr. Field	4	17
Juniors	Adv. drawing and color	1p	Mr. Scheele	6	10
Seniors	Freehand and mechanical	1c	Mr. Newman	10	9
Seniors	Adv. drawing and color	1s	Mr. Scheele	4	1
Seniors	House architecture	9-1	Mr. Newman	6	10
Seniors	House architecture	9-2	R. K. Steward	6	9
Seniors	History of Art	2b-1	Miss Holt	3	23
Seniors	History of art	2b-2	Miss Holt	3	11
Total					651

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN—WINTER TERM, 1920.

Class.	Subject.	No.	Instructor.	Hours.	No. of students.
Freshmen	Machine design	16a-1	Mr. Fairbanks	10	16
Freshmen	Machine design	16a-2	Mr. Stewart	10	13
Freshmen	Machine design	16a-3	Mr. Brattin	10	13
Freshmen	Machine design	16a-4	Mr. Fairbanks	10	23
Freshmen	Machine design	16a-5	Mr. Robertson	10	21
Freshmen	Machine design	16a-7	J. W. Steward	10	16
Freshmen	Machine design	16a-8	Mr. Rising	10	15
Freshmen	Machine design	16a-9	Mr. Stewart	10	17
Freshmen	Machine design	16a-10	J. W. Steward	10	18
Freshmen	Machine design	16a-11	Mr. Rising	10	15
Freshmen	Machine design	16a-12	Mr. Newman	10	12
Freshmen	Freehand drawing	1h-1	Miss Butler	4	17
Freshmen	Freehand drawing	1h-2	Mr. Chapin	4	19
Freshmen	Freehand drawing	1h-3	Mr. Chapin	4	21
Freshmen	Freehand drawing	1h-4	Miss Butler	4	19
Freshmen	Freehand drawing	1h-5	Miss Butler	4	17
Freshmen	Freehand drawing	1h-6	Miss Holt	4	16
Freshmen	Freehand drawing	1h-7	Mr. Chapin	4	21
Sophomores	Descriptive geometry	5b-1	Mr. Fairbanks, Mr. Field	5	15
Sophomores	Descriptive geometry	5b-2	R. K. Steward, Mr. Brattin	5	16
Sophomores	Descriptive geometry	5b-3	Mr. Robertson	5	13
Sophomores	Descriptive geometry	5b-4	R. K. Steward	5	17
Sophomores	Descriptive geometry	5b-5	Mr. Stewart	5	15
Sophomores	Descriptive geometry	5b-6	R. K. Steward, Mr. Brattin	5	14
Sophomores	Descriptive geometry	5b-7	Mr. Field	5	15
Sophomores	Descriptive geometry	5b-8	R. K. Steward, Mr. Robertson	5	15
Sophomores	Freehand drawing and color	1n	Mr. Scheele	10	11
Juniors	Machine design	6d-4a	Mr. Field	3	11
Juniors	Machine design	6d-4b	Mr. Field	3	10
Juniors	Machine design	6d-3	Mr. Field	3	21
Juniors	Advanced drawing and color	1q	Mr. Scheele	6	11
Seniors	Machine design	6f	Mr. Brattin	6	21
Seniors	Advanced drawing and color	1t	Mr. Scheele	4	5
Seniors	History of painting	2e	Miss Holt	3	29
Seniors	Freehand and mechanical drawing	2c	Mr. Chapin, Mr. Newman	10	8
Total					556

TEACHING SCHEDULE DEPARTMENT OF DRAWING AND DESIGN—SPRING TERM, 1921.

Class.	Subject.	No.	Instructor.	Hours.	No. of students.
Freshmen	Machine design	16b-1	J. W. Steward	6	12
Freshmen	Machine design	16b-2	Mr. Rising	6	15
Freshmen	Machine design	16b-3	Mr. Stewart	6	15
Freshmen	Machine design	16b-4	Mr. Robertson	6	17
Freshmen	Machine design	16b-5	Mr. Fairbanks	6	13
Freshmen	Machine design	16b-6	Mr. Rising	6	16
Freshmen	Machine design	16b-7	Mr. Fairbanks	6	15
Freshmen	Machine design	16b-8	Mr. Robertson	6	16
Freshmen	Machine design	16b-9	Mr. Brattin	6	12
Freshmen	Machine design	16b-10	Mr. Fairbanks	6	10
Freshmen	Machine design	16b-11	Mr. Brattin	6	15
Freshmen	Machine design	16b-12	Mr. Stewart	6	12
Sophomores	Freehand drawing	1w-1	Mr. Chapin	4	22
Sophomores	Freehand drawing	1w-2	Miss Butler	4	15
Sophomores	Freehand drawing	1w-3	Mr. Chapin	4	14
Sophomores	Freehand drawing	1w-4	Mr. Chapin	4	19
Sophomores	Freehand drawing	1w-5	Mr. Chapin	4	17
Sophomores	Freehand drawing	1w-6	Miss Holt	4	14
Sophomores	Freehand drawing	1w-7	Miss Butler	4	18
Sophomores	Freehand drawing	1w-8	Miss Butler	4	10
Sophomores	Drawing and color	1o	Mr. Scheele	10	7
Juniors	Mechanical drawing	3a	R. K. Steward	6	4
Juniors	Advanced drawing and color	1r	Mr. Scheele	6	12
Juniors	Machine design	6e	Mr. Field	6	21
Seniors	Freehand and mechanical	3c	Mr. Newman, Mr. Chapin	10	7
Seniors	Steam engine design	8b	Mr. Field	6	2
Seniors	Steam turbine design	8e	Mr. Field	4	3
Seniors	Advanced drawing and color	1u	Mr. Scheele	4	1
Seniors	History of American painting	2d	Miss Holt	3	25
Total					379

Respectfully submitted,
R. K. STEWARD,
Professor of Drawing and Design.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF HOME ECONOMICS.

President F. S. Kedzie,
East Lansing, Michigan.

My dear President Kedzie:

I have the honor to present the following report for the Division of Home Economics for the fiscal year ending June 30, 1921:

PERSONNEL OF THE DIVISION.

Household Science Department.
Miss Mary E. Sweeney, Dean of Home Economics.
Miss Hilda Faust, Professor.
Miss Louise I. Clemens, Assistant professor.
Miss Osee Hughes, Assistant Professor.
Miss May Person, Assistant Professor.
Miss Avis L. Sprague, Instructor.

Household Art Department:
Miss Winifred S. Gettemy, Professor.
Miss Anna Bayha, Associate Professor.
Miss Helen Goodrich, Assistant Professor.
Miss Cecil VanSteenberg, Assistant Professor.
Miss Minerva Fouts, Instructor.
Miss Florence A. Stoll, Instructor.
Miss Ethel Taft, Instructor.

STUDENT ENROLLMENT.

The total enrollment for the year 1920–21 was 425, showing an increase over last year of 72 students. The enrollment by classes was:

Seniors	45
Juniors	73
Sophomores	108
Freshmen	135
Specials	11
Summer School	53
Total	425

INSTRUCTIONAL FORCE.

It was with regret the College accepted the resignation of Dean Mary E. Edmonds who married in the fall. Her service to the institution as an instructor has been most enthusiastic and constructive. To her efforts largely are due the splendid opportunity for service to the State which this division now enjoys. Mrs. Grace Frear resigned in the late summer, and Miss Ruth Kellogg was granted indefinite leave on account of illness in her family in December. The following appointments were made: Miss May Person, formerly State Leader in the Home Demonstration Work of Michigan, as

Assistant Professor in Nutrition; Miss Avis L. Sprague, University of Chicago, as instructor in Institutional Management; Miss Helen Goodrich, University of Chicago, as Assistant Professor of Household Art. For the interval between September 27 and December 1, when the present Dean assumed the administrative duties of the division, Miss May Person was appointed as Acting Dean. To her conscientious service, together with the splendid co-operation of the Home Economics faculty, the success of the year's work is due.

COURSE OF STUDY.

It was deemed necessary by the faculty of the Home Economics division and by the Advisory Home Economics Committee of the General Faculty to make certain revisions in the course of study for the next year, allowing greater range of choice among electives for students beginning with the junior year and higher specialization than is now offered, also to develop a general course which would permit a matriculate to take an elective for each of four years, and while receiving all the fundamental training in home economics, to minor in another subject. The need was also pressing because of the newer opportunities open to home economics graduates as hospital dietitians, visiting housekeepers, county home demonstration agents, clinicians in hospitals, expert buyers for mercantile firms, and cafeteria and lunch room managers.

The evidence of this need for specialized training is shown by the positions accepted by graduates of this year's class, fifteen per cent enter the service of hospitals as dietitians, ten per cent, extension service of the Michigan Agricultural College, one social service field, one State Board of Health, one commercial demonstration, and the rest, teaching.

The following courses to become effective with the fall of 1921, were accepted by the General Faculty and approved by the State Board of Agriculture:

TECHNICAL HOME ECONOMIC COURSE.

FRESHMEN.

FALL.		WINTER.		SPRING.	
English 8j (Composition)	5	English 8k (Composition)	5	English 8l (Composition)	5
Mathematics 1b (College algebra)	5	Chemistry 1 (General chemistry)	5	Chemistry 2 (Qualitative analysis)	5
Home economics 80a (Applied design)	2	Home economics 80b (Applied design)	3	Home economics 50a (Clothing)	5
Botany 21a (Plant anatomy and physiology)	5	Home economics 70	5	Physics 3	5
Drawing 21a (Freehand drawing)	2	Home economics 49 (Development of home economics)	2		
Hygiene (Physical training)	1	Physical training	0	Physical training	0
Total	20	Total	20	Total	20

SOPHOMORE.

FALL.		WINTER.		SPRING.	
Chemistry 3 (Organic chemistry)	5	Chemistry 21a (Physiological) or	5	Bacteriology 1 (General bacteriology)	5
Home economics 1a (Foods)	5	Chemistry 22a (Textile chemistry)	0	Home economics 1c (Foods)	5
*Physiology 1b (Anatomy and physiology)	5	Home economics 1b (Foods)	5	Home economics 50b (Clothing)	3
History 2 (Nineteenth century)	5	Home economics 51 (Principles of clothing selection)	5	Economics 8 (Sociology)	5
Physical training	0	Economics 9 (Economics)	5	Drawing and design 1 (Mechanical drawing or general elective)	2
		Physical training	0	Physical training	0
Total	20	Total	20	Total	20

*Physiology 1b repeated winter term, 1922.

FOOD AND NUTRITION MAJORS.

JUNIOR.

FALL.		WINTER.		SPRING.	
Chemistry 21b (Advance physiological)	5	Home economics 10 (Dietetics)	5	Home economics 11 (Advanced dietetics)	5
Education 1 (Physiology)	5	Home economics 20 (Institutional management)	5	English 9a (Public speaking)	3
General electives	10	General electives	10	Home economics 33 (Home sanitation)	3
				General electives	9
Total	20	Total	20	Total	20

SENIOR.

FALL.		WINTER.		SPRING.	
*Home economics 31 (Home management)	2	Home economics 15 (Special investigation in nutrition)	5	Home economics 16 (Research problems in nutrition)	5
*Home economics 32 (Home management laboratory)	5	**Required electives	3	English 8m (Journalism)	3
Home econimics 12a, 13a or 14a	3	General electives	12	General electives	12
**Required electives	3				
General electives	7				
Total	20	Total	20	Total	20

CLOTHING AND TEXTILE MAJORS.

JUNIOR.

FALL.		WINTER.		SPRING.	
Drawing and design (House architecture) or	3	Home economics 52b (Advanced clothing) or		Home economics 55 (Problems in clothing and textiles)	5
Home economics 53a (Millinery)		Home economics 41 (General nutrition)	5	English 9a (Public speaking)	3
Home economics 52a (Advanced clothing)	5	Home economics 81 (House furnishing)	5	General electives	12
Education 1 (Psychology)	5	Home economics 71 (Textile problems)	3		
General electives	7	General electives	7		
Total	20	Total	20	Total	20

SENIOR.

FALL.		WINTER.		SPRING.	
*Home economics 31 (Home management)	2	Home economics 83 (History, costume and pageantry).	3	Home economics 54 (Clothing problems) or	
*Home economics 32 (Home management)	5	Home economics 82 (Applied design)	3	Chemistry 22b (Textile chemistry)	5
**Required electives	3	Required electives	3	English 8m (Journalism)	3
General electives	10	General electives	11	General electives	12
Total	20	Total	20	Total	20

*Given every term.
**Required elective—3 credit course in either sociology or economics.

VOCATIONAL HOME ECONOMICS—MAJORS.

(Providing qualifications under Smith-Hughes law.)

JUNIOR.

FALL.		WINTER.		SPRING.	
Education 1 (Psychology)	5	Education 2 (Science of education)	5	*Education 1a (Methods of teaching home economics)	5
Home economics 52a (Advanced clothing)	5	Home economics 41 (General nutrition) or Home economics 10 (Dietetics)	5	Home economics 93 (The house)	5
**Home economics 53a (Millinery)	3	****Home economics 20 (Institutional management)	5	English 9a (Public speaking)	3
Home economics 30 (Home care of sick)	3	General electives	5	General electives	7
General electives	4				
Total	20	Total	20	Total	20

SENIOR.

FALL.		WINTER.		SPRING.	
****Education 3a (Practice teaching home economics)	4	****Home economics 31 (Home management)	2	Education 3 (History of education)	5
Elective in English	3	****Home economics 32 (Home management laboratory)	5	Home economics 33 (Home sanitation)	3
***Required electives	3	***Required electives	3	General electives	12
General electives	10	General electives	10		
Total	20	Total	20	Total	20

*Repeated fall and winter terms, senior year.
**Repeated spring term.
***Required elective—either 3 credit course in sociology or economics.
****Given every term.

GENERAL HOME ECONOMICS.

FRESHMEN.

FALL.		WINTER.		SPRING.	
English 8j (Composition)	5	English 8k (Composition)	5	English 8l (Composition)	5
Mathematics 1b (College algebra)	5	Chemistry 1 (General chemistry)	5	Chemistry 2 (Qualitative analysis)	5
Home economics 80a (Applied design)	2	Home economics 70 (Textiles)	5	Home economics 90 (General clothing)	5
Home economics 49 (Development of home economics)	2	*General elective	5	*General elective	5
Hygiene	1	Physical training	0	Physical training	0
*General elective	5				
Physical training	0				
Total	20	Total	20	Total	20

SOPHOMORES.

FALL.		WINTER.		SPRING.	
Chemistry 3 (Organic chemistry)	5	Physiology 1b (Anatomy and physiology)	5	Physics 3 (General physics)	5
Home economics 40a (General course in foods)	5	Home economics 40b (Foods)	5	Home economics 40c (Foods)	5
Required elective	5	Required elective	5	Required elective	5
General elective	5	General electives	5	General elective	5
Total	20	Total	20	Total	20

*General elective freshmen year. General home economics course.

JUNIOR.

FALL.		WINTER.		SPRING.	
Education 1 (Psychology)	5	Home economics 41 (General courses in nutrition)	5	Home economics 93 (The house)	5
Home economics 92 (Design and choice of clothing)	5	Required elective	5	Required elective	5
Required elective	5	General electives	10	General electives	10
General elective	5				
Total	20	Total	20	Total	20

SENIOR.

FALL.		WINTER.		SPRING.	
Home economics 42 (General course in home management)	5	*Home economics 34 (Home care of the child)	5	Elective in clothing and textile	5
Required elective	5	Required elective	5	Required elective	5
General electives	10	General electives	10	General electives	10
Total	20	Total	20	Total	20

*Given every term.
Those desiring a state teachers' certificate must take education 1, 2 and 3.

GENERAL ELECTIVES FOR FRESHMEN GENERAL HOME ECONOMICS COURSE.

*Mathematics 1b	5	Mathematics 2b	5	Mathematics 3b	5
		Mathematics 2		Physics 3	5
		Physics 3e	5	Physics 3d	5
History 2	5	History 5	5	History 1	5
Botany 1a	5	Botany 2a	5	Botany 3a	5
		Zoology 1b	5	Botany 21	5
French 1a	5	French 1b	5	French 1e	5
French 2a	5	French 2b	5	French 2c	5
Spanish 1a	5	Spanish 1b	5	Spanish 1e	5
German 1a	5	German 1b	5	German 1c	5
		History 7	5	History 7	5
Drawing 1b	5	Drawing 1h	5	Drawing 1j	5

*Mathematics 1b is required of all students.

Requirements for the first year elective may be met by taking mathematics 2b, winter term and 3b, spring term, or by taking mathematics 2b, winter and physics 3, spring, or by taking physics 3e, winter or 3d spring.

REQUIRED ELECTIVES IN GENERAL HOME ECONOMICS COURSE.

All students taking the general course in home economics will be required at some time during the four years to complete the following:

1 year modern language	15 credits.
1 term history	5 credits.
1 term English literature	5 credits.
1 term American literature	5 credits.
1 term bacteriology	5 credits.
1 term sociology	5 credits.
1 term economics	5 credits.

DEVELOPMENT OF THE WORK OF THE DIVISION.

Among the gratifying indications of the steady, irresistable growth of the division are the rapid development of field work, and the requests made by business, professional and educational organizations for assistance and direction, some of which are Women's Clubs, State Grange, Mothers' Clubs, Association of Collegiate Alumnæ, State Nurses, Teachers' Associations, Business and Professional Women's Leagues, League of Women Voters, High School Conferences, County Home Demonstration Agents' Meetings, State Allied Dairymen's Association, Vocational Education conferences, Alumni Associations of Michigan Agricultural College.

The pressing demand for home economics trained women in nutrition education, in social service, and in business, and the necessity for women before entering to have had previous opportunity to know the real problems of these fields and to solve them, led to the introduction of the spring term of field work in visiting housekeeping, in hospital dietetics, in nutritional clinics, in commercial cafeterias and in high school lunch rooms.

At the request of Superintendent Frank Cody, a survey of the cafeterias operated in connection with the high schools of Detroit was made by Miss May Person and Miss Avis Sprague of the Home Economics faculty and suggested changes pointed out which would improve the health of the pupils and secure a more efficient use of the equipment and the income.

At the request of the State Board of Health a survey was made of the Michigan State Public School at Coldwater and recommendations made regarding the diet of the children, the combating of under-nutrition prevalent, and a constructive educational program for preventing its recurrence advised.

To gain further home experience and practical application of the theory studied in the class room, the juniors and sophomores have undertaken a month's project in foods and nutrition, consisting of the preparation in the home of family meals, construction of family clothing, management of the entire household, or large quantity cooking for harvest hands and hired help on the farm. All family marketing is to be done by the student, price lists are kept, record of menus, of time required to prepare meals, and of the

expense incurred are made and submitted as part of the report of the project upon their return to the College in the fall.

The alumnæ have undertaken the earning of fifteen hundred dollars to furnish a home economics practice house on the campus. This will mean a valuable asset to the training of women of the division in that it will afford them a real home in which to apply the theory studied in the classroom and in which to work out the problems of home management, family nutrition, house furnishing, labor saving devices for the home, and child care.

The placing of club "C," the women students' boarding club, by the State Board of Agriculture at the disposal of the Home Economics division to be operated as part of resident instruction in institutional management, gives a splendid opportunity for unusual training in all lines of large quantity cooking and the management in feeding daily six hundred persons.

HOUSEHOLD ARTS DEPARTMENT.

The Household Arts courses are planned to train young women to be better homemakers, with a keen appreciation for beauty, economy and technical skill involved in the choice and making of clothing and the choice and arrangement of house furnishings.

A number of changes have been made in the content of courses which have given a wider range to the subject matter offered and a larger field of application on the part of the student.

In Household Art 1, Clothing, the freshmen were given more advanced problems this year, both in the first and second terms. A new project was worked out the second term. Each student did some custom work which consisted of two child's garments (girl's and boy's). The mother of the children selected the type of garment, but consulted with the student on choice of material, color and design suitable to each child. The course gave the students a broader outlook as to uses of household art training outside the teaching field. The work awakened great interest among the students in the business opportunity in opening shops for making children's clothing.

The work in Household Art 3, Textiles, has been broadened in both content and application. A study of raw and manufactured fabrics, chemical effects of laundrying, household and physical tests for identifying fibres has been made. The students are required to make exhibits of suitable materials for underwear, children's play clothing, women's dresses and table linen, to study the use of deodorants on clothing and removal of stains, field trips were made through woolen mills, carpet factories and other industrial plants.

In house furnishings the latter part of the term was given to the execution of several projects in actual furnishing or remodeling of rooms and apartments. The students chose the project and carried out the problem on limited sums to meet local conditions.

The projects included were:

1. Furnishing of the varsity club room, gymnasium.
2. Remodeling girls' rest room on $25.
3. Rearranging and furnishing Y.W.C.A. room on $30.
4. Rearranging and furnishing of small apartment on $25.

In millinery it was possible to increase the amount of work accomplished and to give students some preliminary training in commercial millinery, the latter line of work was especially successful in the making of hats for children.

Advanced Clothing, problems in tailoring and individual clothing project.

Tailoring was offered spring term and consisted of the making of suits, long coats and sport coats under the direction of an experienced tailor, and the choice for a second project of the silk dress, an advanced problem in draping given by Miss Margaret Hoover of the Mills Dry Goods Company, and the making of illustrative material for a high school course in Household Arts. This choice was given as not all the members of the class would teach.

Many of the graduates of the Home Economics divisions do not wish to teach after leaving college, and it is the aim of this department to acquaint the students with some of the opportunities which are open to women in various fields. With further special training these graduates may turn to textile chemistry, costume designing, house furnishing or trained salesmanship.

It was the good fortune of the department to have the opportunity to direct some classes in one of the Lansing clothing stores for a term of five weeks. The class work was carried on by two senior students under the supervision of the educational director. It is felt that this experience has brought into closer sympathy the merchants, the saleswomen, the college instructors and the students, also that it is the beginning of a much larger service which the College can give to its graduates who are interested in the commercial phase of clothing. Future aims are to establish clothing information bureaus over the State. There is a great demand for some practical knowledge that will enable the consumer to buy intelligently and be assured of value received. It is the desire of the department to serve the people of the State by giving out information in the testing of materials and suggestions for selection and to teach the use of the budget by all homemakers.

An effort is made to keep in touch with the development of household arts work throughout the country. The faculty are at present interested in research problems in textbooks and courses of study, with the hope that the results may aid in the standardization of this work in both high schools and colleges, also some of the problems of investigation that are promoted by the committee on the standardization of textiles of the American Home Economics Association are being worked out in the household arts classes in clothing.

During the farmers' week of 1921, February 1 to 5, the junior clothing classes of the Household Arts department arranged an extensive exhibit for the education and aid of the shopper. The slogan was: "Do You Get What You Pay For," and the exhibit including:

Shoes and stockings.
Undergarments.
Wash dresses.
Materials for service dresses.
Household linens.

attracted much attention and gained favorable comment. A table fitted with the necessary equipment for the simple home test of fabrics for adulteration, tested out many samples of materials brought in. A register of visitors showed an attendance of over two thousand during the week.

HOUSEHOLD SCIENCE DEPARTMENT.

Some changes were made in the subject matter content of courses in household science and in the number of lecture and laboratory hours. Advanced Cookery and Problem Cookery which were offered fall and winter terms were not repeated spring term with the consent of the faculty. Household Science, 1a, Foods, was re-organized, beginning with the spring term and planned on the

meal basis with a closer correlation with physiology, physics, bacteriology and chemistry and the application of scientific principles underlying the preparation of food.

Winter term, a section in the advanced dietetics course as part of their laboratory practice, fed daily twenty ex-service students matriculated in the Vocational Educational department. These men were suffering from physical disability due to nutritional and organic disturbances and after medical diagnosis with cooperation of the physician consulted, were fed by the students at special tables in club "C". Each man was placed on a diet, adapted to his ailment, prepared by the class during laboratory or assigned hours. The gains averaged eight-tenths pounds per man per week, the meals were furnished at an average cost of thirty-one cents and all but two men were returned to normal weight which they maintained throughout the six month period. The improvement in spirits, ambition and morale was quite as remarkable as the physical gains made. All the men who stayed at the institution were able to continue their work although when coming to the diet class they had expected to have to leave College on account of their health. The splendid efforts of Professor Hilda Faust made this undertaking successful.

It is a matter of satisfaction that this work received the recognition of the Federal Board of Vocational Education and was made the basis for recommendation to other institutions to take similar care of their disabled ex-service men.

Another section of the class in February, established a nutritional clinic at the Foster street public school of Lansing. This type of work had been planned by Assistant Professor Person and Dean Edmonds before the latter's retirement, but was delayed in being carried our until the winter term. The clinic children were chosen from a selected group who were designated as outstandingly anemic. The class had to be met after school hours, all food was prepared at the College and carried in baskets to the school by the home economics students, the interest and enthusiasm of the children maintained, and the cooperation of the parents secured. It is a tribute to the tireless effort, the insight and knowledge of Professor Person and her students that a hundred per cent attendance was maintained, 256 per cent gain in weight over normal was averaged, and that before the close of the winter term, two other clinics had been requested by the City Board of Health and the principal of the Cedar street school. At all these clinics the senior students with the active cooperation of Dr. Humphrey of the Lansing Board of Health, Miss Hull of Public Health Nursing, Miss Brown of the Social Service Center, and the principals of the schools, did the weighing, measuring and instruction in use of foods, food and health habits, made all charts and kept records. The gain to the student in having the responsibility placed upon her was immeasurable.

The spring term, the General Faculty having given permission, four lines of field work were opened up as a development of the advanced dietetics consisting of nutrition clinics, hospital dietetics, visiting housekeeping and feeding of disabled soldiers. The equivalent of four laboratory hours were spent in each section and one conference hour. The opportunity for training in hospital dietetics was made possible by the cooperation of Mrs. Harry Person, superintendent of Sparrow Hospital, in visiting housekeeping by the cooperation of Miss Ruth Bowen of the Social Service Center. Four additional clinics were requested by the Board of Health at the Logan street school, making a total of seven clinics operated during the spring term.

Twelve students enrolled in hospital dietetics and spent their laboratory hours at Sparrow Hospital working under the direction of Professor Faust.

Five students took visiting housekeeping, first doing case work with aid of social worker, later having assigned to them a special family as a problem. In every case wiser use of the family income was planned, mother was assisted in making family clothing, buying and cooking of food, planning meals. Professor Person is responsible for the excellent manner in which this course was developed.

The feeding of the ex-service men continued during the spring term. Students were made entirely responsible for purchase, preparation and serving of food, each student taking managerial authority for one month. New men were added as for various reasons some left college and the problems were continually changed. This course continued under the supervision of Professor Faust.

The course in Institutional Management was greatly enlarged and during the winter term the laboratory was given in cooperation with club "C", food being prepared by the class for club "C". During the spring term an additional course in large quantity cooking was offered. Students took charge of the high school lunch at East Lansing, planning, preparing and serving the food. Other students did six hours field work per week in commercial cafeterias, tea rooms and high school lunch rooms of Lansing, the purpose of which was to acquaint them with procedure, methods and standards of commercial concerns. Weekly reports were made, conferences held and lectures given. The large quantity cookery, through the cooperation of Mrs. James of Wells Hall, prepared some articles of food for two hundred at each laboratory period. This was done without cost to the division. Many graduates upon leaving the College, are called upon to conduct school lunches in connection with their work, and it is very important that they understand the management, financing and the preparation of food so as to take care of the health of hundreds of children.

HOME ECONOMICS EDUCATION.

The practice teaching work done in the East Lansing high school has greatly improved. The students have been given more responsibility in planning the project during their teaching. Each student has taught larger number of lessons, and next year each practice teacher will teach a minimum of thirty-six lessons. Work has been started this year in the eighth grade and next year will be introduced into the seventh grade. The regular senior high school classes will meet five days a week next year instead of three a week as at present.

Next year practice teaching in clothing and foods will be done at rural schools, the students having complete charge of the course.

A school lunch was started last fall and was carried on by the students doing practice teaching, so they had some experience in school lunch management. This lunch was taken over by the class in institutional management during the spring term due to lack of time in schedule of the student doing practice teaching.

The course in Special Methods has steadily improved and by being offered every term, makes the classes smaller so that much more intensive work can be done.

All the work which has been accomplished during the year in the Home Economics division has been made possible through the magnificent spirit of

cooperation and through the conscientious service of the members of the Home Economics faculty, and through the general spirit of helpfulness and interest manifested by other divisions and by all the departments of the College, and for which I wish to make grateful acknowledgment.

Respectfully submitted,
MARY E. SWEENEY,
Dean of Home Economics.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEAN OF WOMEN.

President Frank S. Kedzie,
East Lansing, Michigan.

My dear President Kedzie:

Permit me to present the following report of the Department of the Dean of Women.

Fifty-eight freshmen have been domiciled in Abbot Hall under the supervision of Mrs. Caroline Lewerenz; sixty freshmen, in Howard Terrace under the supervision of Miss Emily Jones. Waterbury House, College Cottage, and College Residence have housed respectively twenty-six, eighteen and fourteen young women sophomores. Mrs. Sallie Katz, Mrs. Herbert Murdock and Mrs. N. L. Eastman have been in charge of these dormitories. The policies which have proved satisfactory in these five dormitories will be continued the coming year. Mrs. May Stoner Clay, who has been absent for a year, will return to us in September as house mother at Howard Terrace.

Senior House, which has been used as a practice house for eighteen senior girls under the supervision of Mrs. Mildred Osband, will become a dormitory for sophomore girls; the senior girls will have a smaller house upon the campus. In the Womans Building, eighty-five girls have had rooms.

The health of the young women of the College has been noticeably good during the past year, there having been but a very few isolated cases of illness.

The matter to which I wish particularly to call your attention is the progress made by the students in self-government during the past two years. All women students are members of the Womans Self-Governing Association. They elect their own officers and administer the government through a council in each of the dormitories. While self-government, as at present administered, has some weaknesses, it is the most effective means of training our young women for future usefulness, as well as the most effective means of administering discipline with the present day young women. Great credit should be given Miss Dorothy Curts for the wisdom and the faithfulness with which she has met the duties of President of the Council.

I wish to express, my sincere appreciation of the tact and the hearty cooperation shown by the house mothers in meeting this new problem of self-government. I wish to express my sincerest appreciation of the interest and help you have unfailingly given to the solution of the problems of the young women students.

Very respectfully yours,
EUDORA H. SAVAGE,
Dean of Women.

East Lansing, Michigan, June 30, 1921.

ANNUAL REPORT OF THE DEPARTMENT OF TEACHER TRAINING.

President F. S. Kedzie.
Dear Sir:

Personnel of the department:
Walter H. French, Professor.
Mary E. Sweeney, Professor.
E. Lynn Grover, Associate Professor.
Elizabeth J. Frazer, Associate professor.
Josephine Hart, Assistant professor.

The Department of Teacher Training has charge of presenting the courses in education, and directing the practice teaching for those who are preparing to teach agriculture and home economics.

The courses in education for teachers of agriculture are as follows:
Education 4. Educational psychology.
Education 5. General methods and school demonstration.
Education 6. Special methods in teaching agriculture.
Education 6a. Practice teaching.

The courses for women are:
Education 1. Psychology.
Education 1a. Special methods in home economics.
Education 2. General methods and school management.
Education 3. History of education.
Education 3a. Practice teaching.

During the year 59 men in the Agricultural division have taken the courses in education. This number included a part of the senior class in agriculture and part of the junior class in agriculture. Forty-four seniors completed the courses in education and practice teaching and received licenses.

Sixty-eight women entered the courses of education for the fall and winter. These young women were mostly juniors. For the spring term there were forty-eight young women all of whom were seniors. Thirty-seven senior women were graduated and granted vocational certificates to teach home economics.

This department operates under the provisions of the federal law, known as the Smith-Hughes law, and the young men and women will teach for the most part in the schools operating under the said federal law. The purpose of vocational departments of the public schools is to give an opportunity for direct training along vocational lines and so far as we are concerned, we prepare for the vocations of agriculture and home making. The annual report of this department will show the courses given and the expenses connected with the administration of the department. The total expense of the department for the year for instruction, travel and incidental expenses, is approximately $14,000.

Practically fifty per cent of the public schools in Michigan teaching courses

in home economics, employ graduates of the Michigan Agricultural College. At the present time there are sixty-five schools giving vocational courses in agriculture and these are all handled by graduates of this institution. The young men who complete the courses in education do not all enter the profession of teaching. Many of them are our most successful county agents. Others occupy managerial positions and others are professional specialists in agricultural work. The same may be said of the young women who graduate in home economics. A portion of them teach, but many of them become dietitians, nurses, specialists in agricultural chemistry and commercial chemistry, and all of them are taking important places and doing important work in the service of the community.

Respectfully submitted,
W. H. FRENCH,
Director.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DIVISION OF VETERINARY SCIENCE.

F. S. Kedzie,
East Lansing, Michigan.

Dear President Kedzie:

Herewith I present the 11th annual report of the Division of Veterinary Science.

No changes in the personnel of the Veterinary division have occurred during the year just closed; however, some changes in organization and disposition of work is planned for the coming year. There has been the best of cooperation among the faculty and I wish to express my appreciation for its helpful attitude.

The meeting of the American Veterinary Medical Association which occurred August 23rd to 27th, 1920, was attended by Drs. Chamberlain, Hallman, Hutton, Runnells and Sales. The program was excellent and much good was derived therefrom.

The meeting of the Michigan State Veterinary Medical Association was held at the College, February 8th and 9th, 1921, with a record attendance at this meeting. Dr. R. A. Runnells was elected secretary of the Association, it is hoped that we can do much to assist the development and usefulness of the Association to the profession.

The meeting of the United States Live Stock Sanitary Association at Chicago, November 28th to December 2nd was attended by Drs. Chamberlain, Hallman, Hutton and Runnells. This meeting also was instructive and helpful. Several local association meetings, Central Michigan, Michigan-Ohio and Southeastern have been attended by members of the faculty who have taken part in their programs.

Just recently, June 23rd to 25th, inclusive, the Veterinary division has cooperated with the State Bureau of Animal Industry in staging a short school of instruction to assist veterinarians in preparing for the federal examination held at the College, June 25th. The school was well attended (300) and we believe much was accomplished in developing sympathy between the College and the profession and in advertising M. A. C. throughout the profession of the State.

Attempts to increase the student enrollment last year in the Veterinary course were futile; three freshmen enrolled but two of them dropped out, two others transferred to the sophomore class from other courses. The small enrollment of freshmen in the Veterinary course is not a local condition but obtains in all veterinary schools in North America. The following table prepared by Dean White of Ohio State College elucidates that point.

STUDENT POPULATION OF STATE VETERINARY COLLEGES 1920-21.

Name of institution.	First year.	Second year.	Third year.	Fourth year.	Special.	Totals.
Alabama Polytechnic Institute	20	15	12	6	....	53
Colorado Agricultural College	26	22	20	20	....	88
Georgia State Agricultural College	7	7	3	4	....	21
Iowa State Agricultural College	30	24	18	22	....	94
Kansas State Agricultural College	9	20	13	18	1	61
Michigan Agricultural College	1	8	4	8	....	21
New York State Veterinary College (Cornell)	13	32	15	16	2	78
New York State Veterinary College (N. Y. Univ.)	7	3	5	8	....	23
Ohio State University	19	30	30	25	....	104
Ontario Veterinary College (Canada)	24	32	22	17	....	95
University of Pennsylvania	4	8	7	11	....	30
Texas Agricultural and Mechanical College	1	5	2	6	4	18
State College of Washington	3	1	6	12	....	22
PRIVATE VETERINARY COLLEGES 1920-21.						
Indiana Veterinary College	11	28	23	73	1	136
St. Joseph Veterinary College	10	38	16	37	....	100

The above should not preclude the Veterinary course at this College but implies a greater duty to encourage men to take up the veterinary course of study.

In January as of the class of 1920, Mr. A. C. Masten was graduated and June 15th, 1921, the following men received the degree of D.V.M.

Mr. R. E. Bergman.
Mr. H. P. Conrad.
Mr. C. W. Dwyer.
Mr. X. B. Shaffer.
Mr. George Thomas.
Mr. Asa Winter.

The above men will enter private practice with possibly one exception. The small graduation of veterinary students is already evident in a greater number of vacancies in veterinary practice.

DEPARTMENT OF ANATOMY.

The work of this department has been handled by Drs. Chamberlain and Johnson. The former has given courses in Poultry Anatomy in connection with poultry courses 3 and 4 and has been in charge of the Veterinary division. The following table gives an outline of the work done.

ANATOMY.

Term.	No. of students.	Credits.	Lectures.	Laboratory.	Total class hours.
Fall:					
Anatomy 1a	2	4	24	72	96
Anatomy 2a	12	3	....	108	108
Anatomy 4	9	4	24	72	96
Total	23	11	48	252	300
Winter:					
Anatomy 1a	2	4	24	72	96
Anatomy 1b	2	4	12	72	84
Anatomy 2b	11	4	12	108	120
Anatomy 3a	4	4	24	72	96
Poultry 3	20	2½	12	36	48
Total	39	18½	84	360	444
Spring:					
Anatomy 1a	3	4	24	72	96
Anatomy 1b	4	4	12	72	84
Anatomy 1c	9	4	12	108	120
Anatomy 2c	9	3	12	72	84
Anatomy 3a	2	4	24	72	96
Anatomy 3b	7	4	24	72	96
Poultry 4	6	2½	12	36	48
Total	40	25½	120	504	624
Grand total	102	55	252	1,116	1,368

The housing condition for work in anatomy has not changed from that of last year. More microscopic slides and specimens of the chick have been prepared. The courses in Histology and Embryology (anatomy 3a, 3b and 4) have been opened to students of the home economics, agriculture and applied science courses thus enabling them to more fully complete their training for laboratory work.

DEPARTMENT OF VETERINARY MEDICINE AND PHARMACOLOGY.

The courses in Veterinary Medicine and Pharmacology have all been handled by Dr. Taylor for the last year except Medicine 5 (jurisprudence) which was very ably handled by Judge L. W. Carr.

The following table represents the work of this department.

VETERINARY MEDICINE.

Term.	No. of students.	Credits.	Lectures.	Laboratory.	Total class hours.
Fall:					
Medicine 1	7	4	48	....	48
Total	7	4	48	....	48
Winter:					
Medicine 3a	10	5	60	....	60
Total	10	5	60	....	60
Spring:					
Medicine 3b	12	4	48	....	48
Medicine 5	11	1	12	....	12
Total	23	5	60	....	60

PHARMACOLOGY.

Term.	No. of students.	Credits.	Lectures.	Laboratory.	Total class hours.
Fall:					
Pharmacology 2	5	5	48	24	72
Pharmacology 4a	7	3	36	....	36
Total	12	8	84	24	108
Winter:					
Pharmacology 4b	5	3	36	....	36
Total	5	3	36	....	36
Spring:					
Pharmacology 1	8	5	48	24	72
Pharmacology 3	5	4	36	24	60
Pharmacology 4c	7	3	36	....	36
Total	20	12	120	48	168
Grand total	77	37	408	72	480

VETERINARY SCIENCE.

The Veterinary Science for agricultural and short course students has been handled as of last year by Dr. E. K. Sales who has also given the subject Zootechnics to veterinary students. The following table illustrates the work with these subjects.

VETERINARY SCIENCE.

Term.	No. of students.	Credits.	Lectures.	Labora-tory.	Total class hours.
Fall: Veterinary science 2a	22	5	60	....	60
Winter: Veterinary science 2b	17	5	60	....	60
Spring: Veterinary science 2c	14	5	60	....	60
Grand total	53	15	180	....	180

ZOOTECHNICS.

Term.	No. of students.	Credits.	Lectures.	Labora-tory.	Total class hours.
Winter: Zootechnics 1	5	3	24	24	48

This year in the shuffle of courses several changes in the veterinary curricula have occurred thus permitting a strengthening of the course in Animal Husbandry.

See report of Departments of Surgery and Pathology for an account of work in respective departments.

Respectfully submitted,
F. W. CHAMBERLAIN,
Acting Dean.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF ANIMAL PATHOLOGY.

President F. S. Kedzie,
East Lasning,, Michigan.

Dear Mr. President:

I herewith submit report of the Department of Animal Pathology for the year ending June 30, 1921.

The class work for the past year is as follows:

Pathology 2a. Fall term, 5 hours per week, 7 students.
Pathology 1. Winter term 10 hours per week, 8 students.
Pathology 100. Winter term graduate work (minor) 2 students.
Pathology 2b. Spring term, 4 hours per week, 7 students.
Pathology 3. Spring term, 5 hours per week, 7 students.
Veterinary science, short course, 16 lectures, 15 students.

Dr. Runnels has had charge of Pathology 2a and 2b and 3, autopsy work, examination of tissues sent to the laboratory, and class work for short course students. To him is also due the credit for the splendid exhibit put on by the department at the state fair and during Farmer's Week at the College. The major part of the writer's time was spent on his studies of the diseases of the reproductive organs in cattle. The results of this work will be found in his report to the Director of the Experiment Station.

During the year we have held autopsies on two horses, seventeen head of cattle, twenty-three swine, eight sheep, eight dogs, three cats, one fox and one rabbit, one hundred twenty-nine chickens, four doves, four pheasants, two turkeys, one peafowl, one duckling.

Among these we have recorded the following:

Horse,	Canker of feet	1
	Chronic hypertrophic enteritis	1
Calf,	Acute tympany	1
	Acute parenchymatous hepatitis	1
Cow,	Fracture shaft of right ileum	2
Calf,	Monstrosity	1
	Necrobacillosis larynx	1
	Peritonitis	1
Cow,	Pyemia	2
	Septicemia	1
	Tuberculosis	7
Sheep,	Dietary	1
	Forage poisoning	2
	Pneumonia, chronic indurative	1
	Peritonitis	1
Swine,	Acute fibrinous pericarditis	1
	Acute intestinal intoxication	1
	Acute parenchymatous hepatitis with necrosis	1
	Chronic parenchymatous nephritis	1
	Colitis	1
	Cholera	1
	Dietary	9
	Intestinal ascariasis	4
	Ruptured stomach	1
	Verminous pneumonia	2
Dog,	Acute intestinal intoxication	1
	Canine distemper and demodex mange	1
	Intussusception, small intestine	1
	Peritonitis	1
	Thrombosis, jugular vein	1
	Ulcerative stomatitis and ulcerative enteritis	1
Cat,	Intestinal helminthiasis	3
Fox,	Uncinariasis	1
Rabbit,	Acute lobar pneumonia	1
Chicken,	Avian diphtheria	6
	Acute intestinal intoxication	8
	Acute phlegmonous ventriculitis	1
	Bacillary white diarrhea	11
	Coccidiosis	14
	Contagious epithelioma	1

	Dietary trouble	8
	Enteritis	4
	Intestinal helminthiasis	6
	Pneumonia	3
	Rupture of liver	1
	Sarcomatosis	4
	Suffocation due to mechanical obstruction	1
	Tuberculosis	24
	Ulcerated vent	1
Pheasant,	Tuberculosis	4
Pea fowl,	Entero hepatitis	1
Turkey,	Entero hepatitis	2
Dove,	Ruptured spleen	1

During the year we have received for examination, specimens from ninety-nine animals, sent to the laboratory by veterinarians and live stock owners. On account of improper preparation and packing much of this material reaches us in such a condition that a diagnosis cannot be made. Out of this material we have recorded the following cases.

Horse,	Alveolar sarcoma, pharynx	1
	Intestinal strongylosis	1
	Perithelioma, tail	1
Cow,	Actinomycosis	1
Calf,	Acute parenchymatous hepatitis	1
Cow,	Chronic interstitial nephritis and cystitis	1
	Fibroma, vagina	1
	Malignant catarrhal fever	1
	Melano sarcoma	1
	Necrobacillosis	3
	Necrotic pneumonia	3
	Purulent pneumonia	1
	Pseudo leukemia	1
	Tuberculosis	1
Calf,	Sarcomatosis, spleen and liver	1
Sheep,	Hemorrhagic septicemia	4
	Necrobacillosis	1
	Nodular disease	2
Swine,	Catarrhal pneumonia	1
	Fat necrosis	2
	Fatty infiltration liver	1
	Hematoma	1
Swine,	Hemorrhagic enteritis	1
	Hydronephrosis	1
	Melano sarcoma, nose	1
	Pustular dematitis	1
	Suppurative hepatitis	1
	Tuberculosis	2
Dog,	Acariasis	5
	Eczema	1
	Sarcoptic scabies	3
Cat,	Eczema	1
	Necrobacillosis (larynx)	1

Fox,	Acute gastro intestinal intoxication	1
Rabbit,	Lobar pneumonia	1
Chicken,	Hematoma of breast	1
	Pneumonia	1
	Sarcomatosis	5
	Tuberculosis	10
Turkey,	Infectious entero-hepatitis	1

Respectfully submitted,
E. T. HALLMAN,
Associate Professor of Animal Pathology.

East Lansing, Michigan June 30, 1921.

REPORT OF THE DEPARTMENT OF SURGERY AND CLINIC.

President F. S. Kedzie,
East Lansing, Michigan.

Dear President Kedzie:

I hereby submit my fourth annual report of the Department of Surgery and Clinic for the fiscal year ending June 30, 1921. The recitation and laboratory work of the department has been handled entirely by Dr. Sales and myself. The ambulatory clinic has been handled by Dr. McKercher and in a very able manner. In addition to the regular work of the department we have given instruction in Zootechnics 1 and Veterinary Science 2a, 2b and 2c, which is elective for agricultural and forestry courses.

The instruction work for the year together with a tabulated report of the medical and surgical incases and medical and surgical ambulatory clinics is given in the following tables.

Subject.	Fall term.		Winter term.		Spring term.	
	Recitation hours per week.	Laboratory hours per week.	Recitation hours per week.	Laboratory hours per week.	Recitation hours per week.	Laboratory hours per week.
Surgery 1	4	4				
Surgery 2					2	
Surgery 3	4	4				
Clinic 4a				15		
Clinic 4b						15
Clinic 4c		15				
Clinic 4d				15		
Clinic 4e						15
Surgery 5			3			
Surgery 6			4			
Zootechnics			2	2		
Veterinary science 2a	5					
Veterinary science 2b			5			
Veterinary science 2c					5	
Short course veterinary science			5			
Total	13	23	19	32	7	30

A TABULATED REPORT OF THE AMBULATORY CLINIC FOR LARGE AND SMALL ANIMALS TREATED FROM SEPTEMBER 1, 1920 TO JULY 1, 1921.

Medical cases.	Horses.	Cattle.	Sheep.	Hogs.	Dogs.	Cats.	Chickens.
Azoturia	16						
Actinomycosis		2					
Bronchitis		1			2		
Colic, impaction	20						
Colic, spasmodic	12						
Colic, tympanic	4						
Congestion of lungs		1					
Constipation				1	8	1	
Chorea							
Distemper					101		
Dermatitis	1				1		
Eczema					7		
Emphysema lungs	1						
Fleas					1		
Forage poisoning		3					
Gastro-intestinal catarrh of sucklings		2					
Gastro-intestinal catarrh, chronic	1						
Gastritis					3		
Hog cholera				1			
Helminthiasis					3	1	
Intestinal, catarrh		1					
Impaction rumen		15					
Influenza	39						
Indigestion		1				1	
Laryngitis	3						
Lymphangitis	1						
Lice	1						
Mange, demodex					10		
Mange, sarcops						2	
Pneumonia	3	3					
Pleurisy			1				
Pharangitis	2						
Rheumatism					5		
Stomatitis		1					
Strangles	3						
Stomach worms			119				
Tympantis		4					
Tetanus	4						
Traumatic pericarditis		3					
Thumps				1			
Tuberculosis		8					
Total—427	112	46	120	3	141	5	0

A TABULATED REPORT OF THE AMBULATORY CLINIC.—Continued.

Surgical cases.	Horses.	Cattle.	Sheep.	Hogs.	Dogs.	Cats.	Chickens.
Atresia anus		1					
Abscess	2	5			11		
Abortion		7					
Arthritis		1					
Cervicitis		2					
Contusion	12	2					
Choke		1					
Catarract					1		
Caries dentium	1					1	
Castration, simple	7					6	
Concussion of brain					1		
Conjunctivitis	1					1	
Corns	1						
Curb	1						
Castraction cryptorchid	4						
Dystokia	1	7	2				
Dehorning		60					
Distemper vaccination (prophylactic)					5		
Destroyed	1				4		
Endometritis		5					
Exterpation of eye ball					2		
Fracture of pelvis		1					
Fracture of lumbar vertebræ					1		
Fracture of sacrum (mule)	1						
Fracture of radius			1		1		
Fracture of femus					2		
Fracture of tibia					2		
Fistula	3				2		
Fracture of digits					1		
Fistula of withers	10						
Gonitis	1	1					
Goiter		2	1		2		
Gastro hysterotomy					2		
Hip-joint lameness	1						
Hematoma	3				2		
Keratitis	1	1			1		
Laminitis	1						
Luxatious	1	1					
Mastitis		14					
Metritis		6					
Navicular disease	3						
Nymphomonia		1					
Open joint	1						
Otitis					3		
Pyometra		3					
Physical examination		39					
Paralysis					1		
Parotitis	1				1		
Prolapse uterus		1					
Parturient paresis		3					
Parophegia		2		2			
Panaritum		7					
Parophymosis	2						
Pervous urachus	3						
Periodic opthalmia	2						
Paresis post partum		1					
Phlegmon	1						
Pyemic arthritis	1						
Quittor	2						

A TABULATED REPORT OF THE AMBULATORY CLINIC.—Concluded.

Ambulatory surgical cases.	Horses.	Cattle.	Sheep.	Hogs.	Dogs.	Cats.	Chickens.
Ring bone	2						
Retinald placenta		25					
Roarer	1						
Radial paralysis	1						
Stricture teat		4					
Sharp teeth	8						
Spavin bone	7						
Sweeny	2						
Splint	1						
Spavin knee	2						
Sprained tendons	1						
Shoulder lameness	1						
Soundness examination	5						
Teeth extraction	5						
Tuberculin test		152					
Tumor operatable	2						
Tendinitis	1						
Ulcer	2						
Umbilical hernia		1					
Vaginitis		2					
Wound, lacerated	19	3	1 elk		4	1	
Wound, puncture	27				1		
Wound, contused	13	2					
Wound, incised	1				42		
Wound, frost							1
Total 642	170	362	5	2	93	9	1

A TABULATED REPORT OF THE HOSPITAL CLINIC FOR LARGE AND SMALL ANIMALS TREATED FROM SEPTEMBER 1, 1920 TO JULY 1, 1921.

Medical cases.	Horses.	Cattle.	Sheep.	Hogs.	Dogs.	Cats.	Chickens.
Abortion		5					
Amaurosis					1		
Actinomycosis		1					
Azoturia	1						
Bronchitis						1	
Constipation				4	1		
Cervicitis		2					
Coccidiosis							1
Colic, impaction		2					
Colic,spasmodic	7						
Chorea					1		
Distemper					41		
Dermatitis	2						
Distemper vaccination					1		
Eczema					2		
Exhaustion	1						
Edema of sheath	1						
Emphysema of lungs	2						
Forage poisoning		1					
Fleas					1		
Gastro-intestinal catarrh	1	2			1		
Gastritis						1	
Indigestion	1	1			6		
Intussusception of intestines					11		
Influenza	5						
Impaction of rumen		1					
Lice	1	1					
Laaryngitis		1					
Mange, sarcops						1	
Mange, demodex					12		
Necro bacillosis		1					
Nephritis				1			
Paroplegia			1		2		
Poison, strychnine					1		
Purigo	2						
Palpatation of heart	1						
Pleurisy			1				
Pneumonia		1	1				
Ruptured spleen					1		
Roup							11
Strangles	1						
Sarcops, mange						2	
Stomach worms			1				
Tuberculosis		11					
Traumatic pericarditis		2					
Urticaria					1		
Worms round					2		
White diarrhea							80
Total 250	29	30	4	5	85	5	92

A TABULATED REPORT OF THE HOSPITAL CLINICS.—Concluded.

Surgical cases.	Horses.	Cattle.	Sheep.	Hogs.	Dogs.	Cats.	Chickens.
Amputation of tail					22		
Abscess	6	2			1		
Bronchitis						1	
Castraction cryptarchid	1						
Castration, simple	2				5	5	
Contusion	6	1					
Conjunctivitis	6				1		
Canker	1						
Dehorning		22					
Dystokia				1			
Ears trimmed					17		
Empyema	1						
Exterpation of eyeball					1		
Estrum					1		
Extraction of teeth	1						
Fistula	3	2					
Fracture, humerous			1				
Fracture, femur					1		
Fracture, tibia			1		1		
Fracture, metarsus					1		
Fistula of withers	7						
Goiter		1					
Gonitas		1					
Hernia, umbilical		1			1		
Hernia, seratal				[illegible]			
Hematoma	3						
Hernia							
Keratitis	2				2		
Lice	1	1					
Laminitis	1						
Mastitis		2					
Metritis		1					
Navicular disease	2						
Ovariatomy					112	6	
Otitis					6		
Pyometra		1					
Proctitis						1	
Periodic opthalmia	1						
Quittor	3						
Ruptured tendons					1		
Retained placenta		8					
Ring bone	1						
Scab dipping			1 goa				
Shoulder atrophy	2						
Sterility		7					
Spavin bone	1						
Soundness examination	3						
Sharp and irregular teeth	19						
Side bone	2						
Scratches	3						
Stringhalt	1					1	
Spasms of glottis	1						
Sesamoiditis	1						
Stricture of teat		1					
Tuberculin test		[illegible]					
Tendo-vaginitis	1						
Tracheotomy	1						
Tumors	2	1			1		
Tendinitis	1						
Wound, lacerated	7	1				1	
Wound, contused	1						
Wound, puncture	6	1					
Wound, incised					2	1	
Total 381	103	79	3	4	176	16	

The total number of medical and surgical hospital cases treated during the past year was 631.

The total number of medical and surgical ambulatory cases treated was 1,069. This gives us a grand total of 1,690 cases treated by the department during the past year, out of this number 414 were horses, 517 were cattle, 132 were sheep, 14 were hogs, 495 were dogs, 35 cats and 93 chickens. The number of cases treated by the department together with the large variety of material available for instruction purposes has been very satisfactory.

Respectfully submitted,
JOHN P. HUTTON,
Associate Professor of Surgery and Clinic.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE REGISTRAR.

President F. S. Kedzie,
East Lansing, Michigan.

Dear Sir:

I have the honor to present the following report of the Registrar's Office for the year ending June 30, 1921.

In the regular college courses the enrollment for the year is as follows:

Agriculture and forestry	565	
Engineering	523	
Home economics	372	
Veterinary	25	
Total		1,485
Summer school	263	
Graduate course	11	
Total		274
Short courses:		
Two-year, sixteen-week's course in agriculture	154	
Two-year, eight weeks' course in agriculture	66	
Eight weeks' course in farm mechanics	18	
Four weeks' course in poultry	25	
Eight weeks' course in dairy manufacture	16	
Eight weeks' course in dairy production	12	
Eight weeks' course in horticulture	20	
Two weeks' course in cow testing and dairy barn management	19	
Two weeks' course in ice cream making	19	
Four weeks' course in truck and tractor	161	
Total		510
Total in all courses		2,269
Names repeated		233
Net total		2,036

ENROLLMENT BY TERMS.

Course.	Fall.	Winter.	Spring.	Summer.
Agriculture and forestry	519	517	458	134
Engineering	507	467	428	62
Home economics	355	341	332	67
Veterinary medicine	22	22	23	....
Graduate	8	10	9	....
Rural teachers	....	....	....	11
Totals	1,411	1,357	1,250	274

ENROLLMENT BY CLASSES.

	Agr.	For.	Eng.	H. E.	Vet.	Totals.
Graduates	11	....	....	....	....	11
Seniors	87	6	70	45	8	216
Juniors	87	12	88	73	4	264
Sophomores	123	20	150	108	10	411
Freshmen	197	....	214	135	3	549
Special students	22	....	1	11	....	34
Summer session	102	32	62	67	....	263
Rural teachers	....	....	....	....	....	11
Totals	629	70	585	439	25	1,759

GEOGRAPHICAL DISTRIBUTION OF STUDENTS.

MICHIGAN.

Counties.		Counties.		Counties.	
Alcona	1	Gratiot	25	Missaukee	7
Allegan	24	Hillsdale	19	Monroe	14
Alpena	9	Houghton	11	Montcalm	12
Antrim	11	Huron	16	Montmorency	1
Arenac	2	Ingham	244	Muskegon	14
Baraga	3	Ionia	20	Newaygo	12
Barry	12	Iosco	3	Oakland	39
Bay	12	Iron	6	Oceana	18
Benzie	14	Isabella	1	Ogemaw	3
Berrien	30	Jackson	37	Ontonagon	3
Branch	18	Kalamazoo	19	Osceola	5
Calhoun	23	Kalkaska	1	Ottawa	21
Cass	13	Kent	64	Presque Isle	1
Charlevoix	6	Lapeer	20	Roscommon	2
Cheboygan	3	Leelanau	1	Saginaw	30
Chippewa	9	Lenawee	27	St. Clair	34
Clare	1	Livingston	15	St. Joseph	16
Clinton	19	Luce	6	Sanilac	26
Delta	12	Mackinac	2	Schoolcraft	1
Dickinson	4	Macomb	11	Shiawassee	29
Eaton	24	Manistee	7	Tuscola	11
Emmett	8	Marquette	14	Van Buren	20
Genesee	42	Mason	10	Washtenaw	12
Gladwin	3	Mecosta	6	Wayne	89
Gogebic	3	Menominee	2	Wexford	6
Grand Traverse	17	Midland	3		

OTHER STATES AND COUNTRIES.

Alabama	1	Indiana	9	Smyrna	1
Armenia	1	Japan	1	South Dakota	1
Asia Minor	1	Massachusetts	3	South Carolina	1
California	2	Minnesota	4	Texas	1
Canada	1	New Jersey	5	Turkey	2
China	5	New York	21	Vermont	4
Colorado	1	North Dakota	2	Virginia	1
Connecticut	2	Ohio	26	Washington, D. C.	1
Delaware	2	Oklahoma	1	West Indies	1
Egypt	1	Pennsylvania	9	West Virginia	1
Florida	2	Philippine Islands	1	Wisconsin	4
Illinois	25	Russia	1		

STUDENTS ENTERING DURING THE YEAR 1920–1921.

Number enrolled.

Agricultural and forestry course	192	
Engineering course	199	
Home economics course	152	
Veterinary medicine	1	
Graduate students	3	
Total		547

Preparation.

Graduates of accredited high schools	491	
High school credits and examinations	4	
Credits from other colleges	52	
Total		547

DEGREES GRANTED JUNE 15, 1921.

Bachelor of Science.

a, agriculture; e, engineering; h, home economics; f, forestry.

Henry Richard Adams, a.
Harold Dayton Allen, a.
Egnar Sigfred Anderson, e.
Katherine Cornelia Andrews, h.
Arthur Victor Aronson, e.
Frank Winslow Ashton, a.
Karl Deanor Bailey, a.
Morris Joseph Baldwin, e.
Elton Elmer Ball, a.
William Ross Barger, a.
John Oral Barkwell, e.
John Haston Barr, e.
Oscar Richard Beal, e.
Marguerite Beck, h.
Lester Leonard Beltz, e.
Leonard Perry Benjamin, a.
Mildred May Bennett, h.
Thomas Stewart Blair, a.
Richard Irwin Bonninghausen, e.
Elizabeth Marie Burns, h.
Stephana Marie Butler, h.
Mitt McKinley Caldwell, e.
Albert Reinhold Carlson, e.
Edwin William Carlson, e.
Nelson Raymond Carr, a.
Leon George Catlin, a.
Howard Neuman Chapel, a.
Christos Demetrius Christoulias, a.
Ralph Raymond Clark, e.
William James Clench, a.
Ralph Byers Coulter, a.
Oleta Nancy Coverdale, h.
Dorothy Irene Cowin, h.
Catherine Augusta Craig, h.
Wayne Irving Crampton, a.
Laura Hulett Crissman, h.
Guy Edward Culver, a.
Dorothy Bunnell Curtiss, h.
Dorothy Elizabeth Curts, h.
John Sumner Cutler, a.
George Fearson Davis, a.
Arthur Ray Delamarter, a.
Deuell Erwin Devereaux, e.
Paul Eugene Donnelly, a.
John Bernard Donovan, e.
Orville Edward Dunckel, a.
Howard Jay Eddy, f.
Heward Ellis Elmer, a.
Alice Amanda Ewing, h.
Meta Myrtle Ewing, h.
Henry Alvan Fellows, e.
Neal Harris Fenkell, e.
George Ludwig Fick, a.
Herbert West Finnigan, e.
Jane Irene Fitch, h.
Herman Eugene Frank, a.
Charles Lester Frankenfield, f.
Kenneth Stephen Frazier, e.
Herbert Alfred Freeman, e.
Stanley Gaylord Geisler, a.
Arthur Gettel, a.
Frank Henry Gettel, a.
Leopold Paul Ginter, f.
Bruce Francis Gleason, e.
Louis Goldberg, a.
Robert Fitzpatrick Gray, e.
James Gordon Hain, a.
Leonard Emmett Hall, a.
Edwin Carl Hamann, e.
Verne Leon Harris, a.
Harold Yates Hartley, e.
Herbert Bertsch Hartwig, a.
Antoinette Harvey, h.
Everett Elon Hedges, a.
Harris Earl Hemans, e.
Fred Lewis Hendrick, e.
Laura Ellen Hoover, h.
Carl Mead Horn, a.
Beatrice Winifred Hosmer, h.
Leonard Daniel Hoxsie, a.
Frank Sheridan Jacobs, e.
Raymond Francis Jessup, a.
Frank Augustus Johnson, e.
Walter Franklin Jones, f.
Leanore Kenny, h.
Raymond Clarence Kinney, e.
Hugh Alexander Kitson, a.
Henry Jacob Kurtz, e.
Ferris Hunt LaCore, e.
Harlow Emerson Laing, a.
Ellis Robert Lancashire, a.
Theodore Latham Leach, a.
Paul Hercules Lemon, e.
Richard John Liddicoat, e.
Tauge, Gust Lindquist, a.
Lester Carl Lunden, a.
Hervey Augustus Lyon, a.
Pearl Marie McComb, h.
Paul Hughes McCoy, a.
Forest Rees McFarland, e.
Carol Macgregor, a.
Bruce Orlando McKim, a.
Roy MacGlennon Maitland, e.
Wesley Fuller Malloch, e.
Stanley J. Marsden, a.
Clayton Elmer Marshall, a.
Arthur Dexter Martin, a.
Ernest Danela Menkee, e.
Delia Marie Merriman, h.
Erle Nelson Metzen, e.
Gertrude Eliza Meyer, h.
Frances Helen Moak, h.
Earl Raymond Morrow, e.
Dale Talmage Musselman, a.
Russell Ray Nellist, a.
Ferolyn Beatrice Nerreter, h.
George Cleland Nicholls, e.
Hollis William Norman, e.
Geneva Drusa Null, h.
Reynold Gilbert Oas, a.
Charles Howell Osgood, a.
Linus Carl Palmer, f.
Ivan Ward Parks, a.
Joseph Hooker Permar, a.
J. Carleton Perry, a.
Clyde Walter Peterson, e.
Frank Carnahan Pinkham, a.
Harold Jacob Plumb, e.
Gregorio Obdeal Porral, a.
Thelma Elizabeth Porter, h.
Eugene L. Powers, e.
Joseph George Premo, e.
John Joyce Proctor, e.
John B. Ranger, a.
Gertrude Rankin, h.
Maurice Benjamin Rann, e.
June Christine Rapp, h.
William Westbrook Redfern, a.
Esther Marie Rehkopf, h.
Richard Franklin Rey, e.
Fay Sydney Reynolds, e.
David Keith Robinson, e.
Irvin Albert Robinson, e.
Fred Foster Rogers, e.
Lawrence William Ross, a.
Lee Joseph Rothgery, e.
Everett Charles Sackrider, a.
Edgar VanSyckel Sayles, e.
Lyman Christian Schafer, e.
Raymond Martin Schenck, a.
Helen Margaretha Schmidt, h.
Eva Katherine Schurr, h.
Therese Annette Scudder, h.
Marian Ethel Seeley, h.

Loren Shedd, e.
Jen Nan Shu, a.
Clifford Elroy Skiver, a.
Ethel Meredith Smith, h.
Winiford Grace Smith, h.
Floyd Franklin Spaulding, a.
Frederick C. Speidel, a.
Frederick William Spletstoser, e.
Thomas Albert Steel, e.
Romine Carl Stoll, a.
Claude Melvin Stover, e.
Wilma Phyllis Strauch, h.
Ross Charles Stull, a.
Wallace C. Swank, a.
William Floyd Thomas, a.
Annie May Thomson, h.
Charles James Thomson, a.
William Arthur Tobey, e.
Lucy Alexandria Toms, h.
Talcott Miller Tyler, e.
James Tyson, a.
James Frank VanArk, e.
Charles Ernest Watson, e.
Keith Allen Weston, e.
Dorothea Marie Wetherbee, h.
Frank Harmon Weyeneth, a.
Culver Dumont Wilcox, a.
Willfred Brewster Williams, e.
McGlenard Williamson, a.
Walter Kenneth Willman, e.
Sylva Wixson, h.
Eva Hazel Wright, h.
Ralph Emerson Yeatter, a.
Sen Yu, a.

DOCTOR OF VETERINARY MEDICINE.

Roy Edwin Bergman.
Harold Philip Conrad.
Carl William Dwyer.
Xenophon Bryan Shaffer.
George Thomas.
Asa Winter.

MASTER OF SCIENCE.

Leo Joseph Klotz.
Lionel Tisdale.
Hugh Burnice Smith.

CIVIL ENGINEER.

George Percy Springer.

MECHANICAL ENGINEER.

Earl J. Reeder.

MASTER OF FORESTRY.

Edmund Carl Mandenburg.

MASTER OF AGRICULTURE.

Reuben Lovell Nye.

MASTER OF HORTICULTURE.

Ralph Emerson Caryl.
Thomas Hubbard McHatton.

DEGREES GRANTED DECEMBER 17, 1920.

Bachelor of Science.

Gertrude Margaret Beebe, h.
Bertle Gergstrom, a.
George Sawyer Clark, a.
Roy Davis, a.
Edward John Grambau, a.
John Henry Hammes, a.
Kenneth Carson Inselman, a.
Florence Mary Kugel, h.
Cyril Hammond Mains, a.
Clyde H. Mitchell, e.
Marie Lucille Otis, h.
Cornelius V. R. Pond, a.
Florence Eva Rouse, h.
Gertrude Harriett Tappan, h.
Silvere C. Vandecaveye, a.
Helen Marguerite Whitcomb, h.

SUMMARY OF DEGREES GRANTED DURING THE YEAR OF 1920–21.

Bachelor of Science:		
Agricultural course	87	
Engineering course	66	
Home economics course	46	
Forestry course	5	
Total		210
Doctor of veterinary medicine	6	
Master of science	3	
Professional degrees	6	
Total		225

I should like at this time to express my appreciation of the work of Miss Anna Ferle, assistant registrar, and of Miss Delia Bemis, clerk. To them much of the detail work of the office has been assigned and it has been performed in a highly satisfactory manner.

Respectfully submitted,
ELIDA YAKELEY,
Registrar.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE LIBRARIAN.

President F. S. Kedzie,
East Lansing, Michigan.
Dear Sir:

I have the honor to present the following report on the library for the year ending June 30th, 1921.

During the year 866 bound volumes have been added to the library, of which 532 were purchased, 45 were gifts, and 289 came by binding.

Of unbound volumes and pamphlets, 78 were received, all of which were acknowledged when received. We therefore omit individual mention.

For bound volumes coming to us as gifts, we are indebted as follows:

Beadle, Western wilds and the men who made them.
Butter making. McKay.
Ingersoll Watch Co., Time telling through the ages, Brearley.
Iowa, 1.
Kansas horticultural society, 1.
Kentucky, 1.
Massachusetts, 1.
Michigan, 24.
Michigan Academy of Science, 1.
New Hampshire, 1.
President's office, 1.
Missouri, 1.
Successful Farming Pub. Co., 2.
Smithsonian Institution, 4.
U. S. Dept. of Agriculture, 2.
U. S. Dept. of Commerce, 1.
United States Brewers' Assoc., 1.

In addition to the periodicals purchased by the College and the Experiment Station, the library receives the following publications as exchanges or as gifts from publishers.

Aberdeen Angus journal.
Academy of Nat. Sci., Phila., Proceedings.
Agricultural digest.
Agricultural gazette of Canada.
Agricultural gazette of N. S. Wales.
Agricultural review.
Allegan gazette.
America.
Am. Assn. for Intl. Conciliation. "International conciliation".
Am. assn. of univ. prof., bulletin.
American bankers' assn. journal.
American farming.
American food journal.
American fruit grower.
American issue.
American miller.
Am. philosphical society, proc.
American poultry advocate.
American school board journal.
American seedman.
American sheepbreeder.
Am. Steel and Wire Co., crop repts.
American swineherd.
Australasian.
Australian museum, records.
Bean bag.
Belding banner.
Berkshire world and cornbelt stockman.
Better business.
Better fruit.
Board of agri. (London) leaflets.
Board of agri., (London) journal.
Boletin de agriculture, Sao Paulo.
Boston museum of fine arts, bull.
Brooklyn botanic garden, leaflets.
Brooklyn botanic garden record.
Buick bulletin.
California, agri. dept. monthly bull.
California agri. dept. monthly bull., experiment station.
California acad. science, proc.
California citrograph.
California univ. pub. in agri. sci.
California univ. pub. in zoology.
Canadian horticulturist.
Chester white journal.
Cloverland magazine.

Com. reports. Issued daily by U. S. dept. of com., bureau foreign and domestic commerce.
Congressional record.
Constitutional review.
Dairy record.
Dakota farmer.
Detroit educational bulletin.
DuPont magazine.
Duroc bulletin.
East Lansing community life.
Eaton Rapids journal.
Electric traction.
Electrical trade.
Elgin dairy report.
Etude.
Farm and fireside.
Farm journal.
Farmer's advocate.
Farmington enterprise.
Field illustrated and system on the farm.
Florida entomologist.
Flour and feed.
Flower grower.
Fruit belt.
Grand Rapids public lib. bulletin.
Green book.
Guaranty Trust Co., N. Y., letters.
Hawaiian forester.
Highway magazine.
Hoard's dairyman.
Holcad.
Hospadar.
Il giornale d' Italia agricolo.
Illuminating engineer.
Illustrated review.
Improvement era.
India, agr'l research inst. Pusa. bull.
India agr'l research inst., Pusa. agr'l j'l of India.
India agr'l research inst., Pusa. Memoirs, bacteriological series.
India, dept. agri. agri. inst., Pusa. Memoirs, botanical series.
India, dept. agri. memoirs chemical series. Agri. research inst., Pusa.
India, dept. agri., memoirs, entomol. ser. agri. research inst., Pusa.
Indiana farmer's guide, *formerly* Farmer's Guide.
Indiana's friend.
Indicator.
Ingham county news.
Internatl. inst. agri., annuaire international de statis tique agricole.
Internatl. inst. agri., bureau of economic and social intelligence.
Internatl. inst. agri., Rome, bureau of statistics.
Internatl. inst. agri., Rome, bureau of stat., doc. leaflets.
International inst. agri., Rome. Monthly bull. agri., intelligence of plant diseases.
Invest. bks'. assn. Am., bulletins.
James' barn magazine.
Japan review.
Jersey bulletin.
Johns Hopkins univ., circulars.
John Hopkins university, studies.
Jonesville independent.
Journal of agricultural research.
Journal of agriculture., Victoria.
Journal of agri. and horticulture.
Jl. of the college of agr., Tohoku., imperial univ., Sapporo, Japan.
Jl. of college of sci., imp. univ., Tokio.
Jl. of the dept. agri., S. Australia.
Journal of the U. S. artillery.
Livestock report (Clay, Robinson)
Market growers journal.
The market reporter.
Message of the east.
Mexican review.
Miami conservancy bulletin.
Michigan business farmer.
Michigan farmer.
Michigan history magazine.
Michigan library bulletin.
Michigan out-of-doors.
Michigan patron.
Midland naturalist.
Midland sun.
Mo. botanical gardens, annals of the

Moderator topics.
Monthly bull., state com. horticulture, Sacremento, Cal.
Monthly crop reporter.
Natl. education assn., bulletin.
National farmer.
National grange monthly.
National provisioner.
National stockman and farmer.
National weather and crop bull.
Nature—study review.
New York bot. garden, bull. of the
N. Y. meteorology (Draper's hourly readings).
News bulletin.
The North Am. veterinarian.
Official gazette, U. S. pat. office.
Ohio farmer.
"OK" poultry journal.
Open road.
Orange judd farmer.
Our dumb animals.
Pacific dairy review.
Pan American union, bulletin.
Canal record.
Philippine agri. review.
Philippine agri. and forester.
Power farming.
Practical farmer.
Prairie farmer.
Professional engineer.
Progressive farmer and southern farmer gazette.
Psychological bulletin.
Public health reports.
Reclamation record.
Reliable poultry journal.
Rhodesia agricultural journal.
Rice institute pamphlet.
Rockefeller inst. for med. research, studies.
The rotarian.
Russian information bureau in the U. S. bulletin.
School life, U. S. dept. of the inter., bureau of.
Science and industry (Australia).
Seed world.
Shorthorn in America.
Smithsonian inst., bull. U. S. nat. museum.
Smithsonian inst., contrib. U. S. nat. herbarium.
Smithsonian inst., misc. collections.
Successful farming.
Sultanic agri. soc., bulletins, (tech. section).
System on the farm.
Union bulletin.
Union of south Africa., journal of the dept. of agri.
U.S. dept. agri., plant industry library., current author entries.
U. S. dept. of Agri. bur. of public roads.
U.S. dept. agri., monthly weather review.
U.S. library of congress, monthly list of state publications.
Monthly catalogue U. S. pub. doc.
The vocational summary, U. S.
Wallaces' farmer.
Washington farmer.
Washtenaw post.
Weekly news letter.
West indian bulletin.
Wilson bulletin.

The publications of the U. S. Department of Agriculture, and the bulletins of the various state experiment stations, together with the card indexes which render them of easy access, are received and filed in the library.

We also receive the catalogues of the leading educational institutions in exchange for our own catalogue.

The number of books loaned for home use during the year was 7,903, an average per month of about 659. No record can be kept of books used in the library.

We gratefully acknowledge our indebtedness to the librarians of the United States Department of Agriculture, the University of Michigan, the University of Wisconsin, the University of Chicago, the John Crerar library, and the Library of Congress for their courtesy in loaning to us certain publications needed by our research workers.

It is with regret that we record the resignation of our assistant Miss Palm, who has accepted a position in the College of Agriculture of Oregon, as head of the circulation department of the library.

In the reference department much has been accomplished by Miss Feldkamp, reference librarian in charge. Packages covering 138 subjects have been assembled and are ready for circulation. Two hundred eighty five letters, addressed to teachers of agriculture and home economics, county agents, the Farm Bureau, and the leaders of boy's and girl's clubs have been sent out, and 30 packages have been loaned.

Bibliographies on the following subjects have been prepared by request of members of the College extension force.

Cost accounting for cooperative associations.

Cooperative stores.

Pure fabric law.

Cost of keeping horses.

Agricultural credit.

Prices.

For members of our faculty exhaustive references covering the following subjects have been prepared.

Farm management terminology.

Cafeterias.

Construction and operation of windmills.

County government.

The manufacture of charcoal.

The efforts we are making to bring the farmers of the State in closer touch with the College through the extension of library privileges, seems to be quite generally approved, and many letters expressing appreciation of this service have been received.

For our student assistants, Mr. T. G. Lindquist and Mr. G. W. R. Baldwin, we have only words of commendation. Mr. Lindquist was graduated this year. Mr. Baldwin will remain through the coming year.

To the library of the Experiment Station 148 bound volumes have been added, of which 22 were purchased, 15 were gifts, and 111 came by binding. This library now numbers 4,933 volumes. The College library contains 41,524 volumes. Total in both libraries, 46,457 volumes.

Respectfully submitted,

LINDA E. LANDON,

Librarian.

East Lansing, Michigan, June 30, 1921.

REPORT OF DIRECTOR OF SUMMER SCHOOL.

President F. S. Kedzie, Agricultural College,
East Lansing, Michigan.

Dear Sir:

The following is a report relative to the Summer Session for the season 1921:

This is the eighth annual session. In accordance with the policy of previous years, the session was organized along the same lines as heretofore. We continued to offer a large nunber of courses taken from the regular curriculum. As a result we found a larger number of our regular students taking summer work this season than ever before. There can be no disputing the fact that the summer session is of inestimable value for the regular student since he is using it, in increasing numbers, for removing deficiencies, shortening his course, or obtaining desirable courses in addition to the regular subjects of his course.

As in several previous years, special courses in agriculture, home economics, club work, and pedagogy were offered for the benefit of rural teachers. An experiment in this connection was undertaken. A well-trained and experienced teacher of grades, in the person of Miss Effie Caskey, County Normal Instructor, of Ionia, Michigan, was engaged to teach a group of miscellaneous school children from East Lansing as a means of demonstrating methods of handling a rural school. The rural teachers in attendance observed this teaching and then discussed with the critic teacher the many pedagogical matters involved in such instruction.

The practice of previous years of holding conferences was continued, including the Boys' and Girls' Club, the Rural Conference, and Economics Conference. The programs were arranged in accordance with the interests of the various groups which included all told, several hundred people. The Economics Conference was held in cooperation with a group of rural people who camped upon the college grounds during their stay. These programs, in addition to using our own faculty members in various capacities, brought to the campus many excellent speakers whose presence here was not only an attraction to the special groups but they were a source of inspiration to regular students and teachers. Conspicuous among the imported talent were Dr. Thomas N. Carver of Harvard University, whose work in the line of agricultural economics ranks as the foremost in the land, Dr. Ernest Burnham of the Western Normal, a very popular speaker and student of education, who gave a series of addresses. Dr. G. F. Warren of Cornell University, was present and discussed the subject of price of agricultural products. Hon. L. L. Driver, State Bureau of Education, Pennsylvania, talked on school consolidation.

A very important group of summer students consisted of public school teachers, about twenty in number, who are preparing themselves for teaching under the Smith-Hughes law pertaining to the teaching of agriculture in the existing high schools, and especially in the agricultural high schools now in the process of organization in many parts of our State. These men are graduates of liberal arts institutions for the most part, and are experienced teachers who come here to get agriculture. The summer school enables them to do

much of this work at that season, at least to reduce the residence to one year. We have students on the campus who are now completing the year for our degree. This is a splendid feature of the session. More of such students should be encouraged to come to us, upon liberal terms.

It has been the aim of the management of the summer session to find the fields of service peculiar to the College, and to refrain from entrance upon the territory of other institutions. This policy has been adopted for obvious reasons. Duplication of facilities in an already well-occupied field, is undesirable; the special facilities of colleges such as this are not only desirable, but are in great need. Faith in this attitude grows stronger with each summer's experience.

Respectfully submitted,
E. H. RYDER,
Director of Summer Session.

East Lansing, Michigan, June 30, 1921.

REPORT OF ALUMNI RECORDER.

President F. S. Kedzie,
East Lansing, Michigan.

Dear Sir:

The following is the annual report of the Alumni Recorder beginning July 1, 1920, and ending June 30, 1921.

During the year we have been adding considerably to our alumni records and making the individual records of alumni and former students much more complete. The activities of the local associations and groups of alumni have helped put us in touch with a great many with whom we had lost contact. Besides the "base" or history cards for all graduates, totaling 3,677, we now have such cards for 3,100 former students who did not complete their courses. As stated in our last report, these cards give the home address, class and course, college activities, and changes of occupation and address since leaving college. During the past year in addition to cards already made, we have completed records for 800 additional former students and 216 graduates, bringing our total number of base cards to 6,570. The new visible index files which were added to our equipment early in the year, have greatly facilitated the keeping of these records. It is believed that our records are more complete and up to date and that alumni service rendered by means of them is better than it has ever been before.

During the past winter an attempt was made for the first time to get "alumni" records for our short course men. A large number of inquiry cards were sent out and through them, we have been placed in touch with about 400 former students of our short courses. During the coming fall and winter, it is planned to make a further circularization in an attempt to extend our information and our contact among this group of former students.

During the year, nine new local alumni associations have been formed, those of Barry county, South Haven, Alpena, Calhoun county, Clinton county, Ionia county, Washtenaw county, Buffalo, New York, and Western Pennsylvania. Four existing associations, those of Jackson and Lenawee county and Saginaw and Bay City, have been reorganized and are now on a

much firmer basis than formerly. There is now a total of thirty-six local associations. A number of the larger organizations hold weekly meetings and nearly half of them have regular monthly meetings. There seems to be a greater interest to do something for M. A. C.

Besides the regular Home Coming, Farmers' Week, and Commencement meetings of alumni at the College, M. A. C. Associations in different parts of the country have held sixty-five meetings of graduates and former students during the year. This does not include the regular weekly luncheons of the Central Michigan or the Detroit Clubs, nor the monthly and semi-monthly meetings of Grand Rapids, Flint, Chicago and Saginaw M. A. C. people. The commencement reunions just past were attended by nearly 800 graduates and former students and it is thought to be the largest reunion since the semi-centennial in 1907. This commencement reunion and the large number of meetings held during the year are something of an indication of the interest that alumni are taking in the College.

Because of the financial situation during the past year, nothing has been done by the M. A. C. Association on the Union Memorial Building campaign fund which was started last year. It is expected however, that it will be resumed during the coming fall and winter. The committee however, have determined that the building shall be worthy of the efforts of M. A. C. men and women, and have determined to build a building to cost $500,000. They have engaged the firm of Pond and Pond, architects of Chicago, to construct the building, in cooperation with the college architect.

Following are the resolutions of the M. A. C. Association, passed at the annual meeting June 15, 1921.

RESOLUTIONS PASSED BY M. A. C. ASSOCIATION AT THE ANNUAL MEETING JUNE 15.

The alumni reunion of 1921 brings its train of important events. The old College never looked better, and its future was never brighter. We feel more proud of being Michigan Aggies now than ever before. Yet we realize that the College cannot be operated on the methods of the past, just as it cannot with the money of the past, and that the administrative and teaching force must be continually changing. In this connection we greatly dislike to bid farewell to President Kedzie, who has devoted some faithful years to the discharge of the most important of all the college offices. We are sensible of the fact that he accepted the office of president only under strong pressure, and that he undertook its duties only for a few years. The Kedzie smile will be much missed from the corner room of the Library Building, and we only wish it might have been housed in more spacious quarters, while discharging the presidential duties. To students of the past, "Uncle Frank" will always be his favorite title. Seldom is it given to mortal man to have such an aggregation of nieces and nephews. We hope that he may in some way continue to be associated with the College in days to come.

We have no favorite candidate to promote for the office of president of the College. Yet we express our conviction that, whoever he may be, he should be a man of wide experience as an educator and administrator. We believe he should be a man of strong religious convictions, in common with other college and university leaders of the day. In this we are but reflecting the expressed beliefs of not a few members of the faculty. Many alumni remember with deepest pleasure and gratitude the hours spent at the home of the president and other faculty members in social converse, and this suggests to us

that the opportunities for influencing the lives of the students by the president and his family through personal contact, makes it highly desirable that the incoming president have his home in the college community. We hope that the Board of Agriculture will not hesitate to pay such salary as may be necessary to secure the right type of leader for M. A. C.

The action of the faculty and Board of Agriculture in inaugurating the science course meets with our enthusiastic approval, and we bespeak for this course a wide publicity and suggest the engagement of an experienced dean who will be able to make for this course an honored place in the list of courses.

The number of students at M. A. C. is a topic much talked about. We are not of those who believe that an attendance of fifteen hundred or so is the most desirable number of students for this College. We believe that the investment in property and equipment here, and the increased investment of future years, requires as large an attendance as can be secured. We hope for a student body of 2,500 in three years, and we believe it entirely possible. Nor do we believe that the enrollment should stop there.

We hold that the payment of adequate salaries is essential to an efficient teaching force and we earnestly hope that there will be no tendency toward a reduction of the salary scale adopted by the State Board in 1920.

We extend greetings to Doctor Beal, the youthful friend of M. A. C. who once again is with us for commencement reunions.

Recognizing the position of the past legislature in regard to the matter of taxation, we express our approval and appreciation of their action in appropriating funds for the building of an Administration Building and a Home Economics Building, and the funds for the extension work.

We recommend that the president of the M. A. C. Association appoint a committee on legislation to represent the College in state politics which have reference to M. A. C. We also recommend that the president of the M. A. C. Association appoint a committee to interest themselves in the election and selection of future candidates for the State Board of Agriculture.

We believe that the M. A. C. should have eventually an appropriate and formal entrance to the college grounds, and suggest to the State Board that they provide for some such suitable entrance in the plans for development of the campus.

Realizing that the financial conditions of the country have been adverse to the progress of the Memorial Building fund, we however believe and ask that this project be pushed onward to its goal as soon as conditions will warrant.

In recognition of the hardy interest and untiring efforts of Harris Thomas as the president of the M. A. C. Association, we express to him our appreciation for his work of the past year and recommend that he be reelected to the office of president.

The recent movement by the alumnæ in their work for the furnishing of a practice house on the campus is a progressive step and the alumnæ are to be commended for their constructive interest in the College.

The death of Mrs. Collingwood has left a gap in the college community. Her work for the student aid fund and her loyal interest in M. A. C. will continue to bear fruit for many years to come. She is an example to us all of what a person can do who loves young people and wants to be of service to them.

Word has come of the very serious illness of former Professor Weil, Dean of Engineering preceding Dean Bissell. We suggest that the secretary be

instructed to send an expression of the sympathy of M. A. C. alumni to Mr. Weil.

(Signed) E. E. HOTCHIN, '12, *Chairman.*
N. A. McCUNE, '01.
MRS. VERA GRUNER OVIATT, '16.

Respectfully submitted,

C. W. McKIBBIN,
Alumni Recorder.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE HEALTH SERVICE.

To the Honorable State Board of Agriculture and Health Service Committee:

We submit the following report of health service activities at the Michigan Agricultural College from October 1, 1920 to June 30, 1921.

In general the health of the student body has been good this year, and with the exception of an epidemic of mumps there have been but few cases of contagious disease.

All freshmen and new students received complete medical examination during the first month of the school year. This part of our work and also consultation and conferences with women students has been seriously handicapped throughout the year because there is not a woman physician on the health service staff.

During the year two hundred and nineteen students have been vaccinated and twenty-eight received typhoid prophylaxis at the Health Service. A large number of these were freshmen who had never before been vaccinated.

A series of health lectures including personal hygiene, first aid, rural sanitation, and sex hygiene was given to all freshmen and new students, including the short course students.

No deaths have occurred this year among students who were under Health Service care.

STATISTICAL.

	Dr. Reynolds.	Residence office.	Hospital calls.	Total.
Dispensary calls	5,070	83	1,081	6,234
New patients	1,175	10	....	1,185
New diagnoses	3,167	53	....	3,220
Room calls	71	....	....	71
Hospital bed patients	....	....	....	165

CONDITIONS TREATED,

Abrasion	2
Abscess	4
Acne	29
Adenoid mouth	5
Adhesions	1
Albuminuria	2
Alopecia	1
Amaurosis	1
Amenorrhea	2
Anaemia	1
Anaphylaxis	1
Animal bite	1
Ankylosis	1
Aortic disease	3
Aortic regurgitation	1
Appendicitis, acute	5
Appendicitis, chronic	4
Arrhythmia	4
Arsenic poisoning	1
Arthritis	4
Asthenopia	44
Asthma	2
Atrophy	1
Attached lobes	2
Broken arch	3
Bronchitis, acute	20
Broncho pneumonia	1
Burn	17
Carbuncle	2
Cauliflower ear	3
Chalazion	5
Chicken pox	3
Clavis	4
Cleft palate	1
Color blindness	3
Congential deviate	1
Conjunctivitis, acute	10
Constipation	10
Cyst	2
Dacryocystitis	1
Deafness	8
Dental caries	29
Dermatitis; calorica	1
Dermatitis; eczematoid	1
Dermatitis; mycelial	2
Dermatitis, seborrhoic	3
Dermatitis, venenata	15
Deviated septum	90
Diarrhea	1
Dislocation	4
Dyshidrosis	6
Dysmenorrhea	1
Eczema	6
Emphysema	1
Enteritis, toxic	37
Epididymitis	4
Epilepsy	1
Epistaxis	5
Erythema, exudative	1
Erythema, multiform iris	2
Erythema, toxic	5
Fissure	6
Flail joint	1
Flat chest	1
Flat foot	22
Folliculitis	1
Foreign body	25
Fracture	15
Frost bite	1
Furunculosis	96
Ganglion	1
Gastritis, chronic	1
Goitre, exophthalmic	4
Goitre, simple	20
Hammer toe	1
Harelip	1
Hay fever	4
Heatstroke	1
Hematuria	1
Hemorrhage	3
Hemorrhoids	11
Hernia	11
Herpes, simplex	19
Herpes, zoster	5
Hiccup	1
Hordeolum	24
Hydrocele	1
Hygienic advice	7
Hyperchlorhydria	20
Hyperhydrosis	4
Hypertension	2
Ileo sacral arthritis	1
Immunization, anti-typhoid	28
Immunization, anti-tetanus	3
Impacted cerumen	28
Impetigo contagiosa	23
Indigestion, acute	1
Infection, local	120
Ingrown toe nail	5
Insect bite	1
Intertrigo	1
Iritis	1
Jaundice, acute catarrhal	20
Joint mouse	1
Lagrippe	4
Laryngitis, acute	10
Leucorrhea	3
Lost arm	1
Lost eye	1
Lymphadenitis	7
Lymphangitis	3
Menorrhagia	1
Metorrhagia	1
Mitral disease	11
Mumps	90
Myalgia	34
Myocarditis	1
Myopia	1
Myringitis	4
Naevus	1
Naso-pharyngitis, acute	52
Nephritis, acute	1
Neuroma	1
Night blindness	1
No disease	129
Observation	54
Operation, appendicitis	4
Orchitis, acute	13
Otitis media, acute	3
Otitis media, chronic	5
Paralysis, resid, ant. polio	1
Paraphimosis	1
Paronychia	7
Perforated septum	1
Peritonitis	1
Pharyngitis, acute	147
Phimosis	10
Phosphaturia	1
Physical examination	613
Pigeon breast	1
Pityriasis rosea	1
Planter wart	1
Pleurisy	7
Prolapse of uterus	1
Psoriasis	3
Pyorrhea	2
Quinsy	3
Refer, private physicians	79
Refractive error	33
Rest	2
Retroversion	1
Re-vaccination	9
Rheumatic fever, acute	3
Rhinitis, acute	87
Sacralization	1
Scabies	12
Scarlet fever	2
Scoliosis	1
Scotoma, scintillating	1
Shoe pressure	5
Sinusitis, acute	12
Small pox	1
Spinal curvature	1
Sprain	61
Synovitis	1
Tachycardia	5

Tachycardia, paxorysmal	3	Undiagnosed	2
Teno-synovitis	12	Unerrupted molar	8
Tinea, axillaris	1	Urethritis, acute	1
Tinea, circinata	2	Urticaria	2
Tinea, cruris	19	Uterine polypus	1
Tinea, versicolor	4	Vaccination	219
Tonsilitis, acute	84	Vaccination inspection	98
Tonsillitis, chronic	129	Vaccinia	1
Tonsilolith	1	Varicocele	5
Tophus	1	Varicosis	1
Tracheitis, acute	127	Verruca	10
Trauma	175	Verruca vulgaris	1
Tuberculosis	1	Vincents angina	1
Tuberculosis suspect	3	Vitiligo	1
Ulcer	3	Wound, gun shot	2
Ulcer, gastric	1		

LABORATORY.

Urines	463	Smear:	
Sputum	2	tonsil	11
Blood, Wasserman	9	urethra	1
Blood count	8	Culture:	
		tonsil	15

HOSPITAL.

College hospital	162	Sparrow hospital	3

I. Total net income	$6,632 34
(a) Apportionment	1,000 00
(b) Student fees	6,079 50
(c) Receipts	552 85
II. Total expenditures:	
without salaries	6,931 97
with salaries	13,405 37
(a) Salaries and wages	6,345 40
(b) Health service:	
without salaries	4,554 44
with salaries	8,569 84
(c) Hospital:	
without salaries	2,377 53
with salaries	4,835 53
(d) Private hospitals	202 50
(e) Outside physicians' and surgeons' fees	851 60
III. Summarized expenditures:	
(a) Total cost per student enrolled:	
without salaries	5 42
with salaries	9 93
(b) College hospital expense per student enrolled:	
without salaries	1 64
with salaries	3 30
(c) Private hospital cost per student enrolled	14
(d) Fees to outside physicians per student enrolled	57
(e) Cost of health service dept. per student enrolled:	
without salaries	3 06
with salaries	5 91
(f) Hospital expense per patient per day:	
without salaries	4 85
with salaries	8 84

(g) Cost per dispensary call:

without salaries..............................	$1 64
with salaries..............................	3 78

Respectfully summitted,
CLYDE REYNOLDS, M.D.
Director of Health Service.

East Lansing, Michigan, June 30, 1921.

REPORT OF MICHIGAN WEATHER SERVICE.

The past year has been one without any startling or unusual features from the administrative standpoint. The general policy of the service has continued as in former years.

The close of the war, however, has marked a period of increased demand for weather data of all kinds.

The number of observation stations in the State has not been increased and the work of the observers, as a whole, has been of a high order. All stations are fully equipped with standard instruments and for most of the stations it can be said that the observation work is continuous.

The distribution of daily forecasts through cooperation with various telephone companies continues to be somewhat abridged. As in the year previous, telephone wires and telephone employees are generally working at peak capacity, and in order to take care of regular commercial business it has been necessary for some telephone companies to give the distribution of forecasts less consideration than is desirable, either on the part of the companies themselves or on the part of the Weather Bureau.

It is interesting to note at this time, that great progress has been made in the perfection of the wireless telephone.

At this time the United States Bureau of Standardization is devoting much time and experimentation in producing a wireless telephone of moderate cost, that may be within reach of the ordinary farmer.

The Weather Bureau has for some time past been sending out daily forecasts for all kinds of interests, principally for the farmers, for the marine shipping interests, and for aviation interests.

The forecasts are sent out at 10:30 A. M. from the radio station at Arlington. These radiograms are in telegraph code and are being picked up in all parts of the United States. It is hoped that the Weather Bureau will send out the same forecasts by wireless telephone in the near future, and when that practice is instituted, anyone, and particularly the farmer, may be able to take down his own instrument and listen in at 10:30 A. M. and get the forecast for the period covered by the "tonight and tomorrow". The arrangements for this wireless telephone of forecasts is already so far advanced that it will be only a question of less than a year before it is in actual practice. If the individual wireless telephone can be brought down to a price that is popular and possible for the average farmer, it will mark a distinct advance in the life of all rural communities, not only from the standpoint of getting the weather telephone messages but also much other information.

The publication of the monthly bulletin has been continued in abridged form since last year and continues to be widely sought for and extensively consulted.

The weekly weather and crop bulletins have continued to be issued during the planting, growing, and harvesting seasons, and are distributed to a considerable mailing list, besides being published in daily and weekly newspapers.

The administrative work of the central office is very heavy on account of a constant demand for all sorts of meteorological information. The monthly bulletins are doing much in a new field that our data has not heretofore touched —that is, in the development of Michigan as the summer playground of the country.

C. F. SCHNEIDER,
Director.

Grand Rapids, Mich., June 30, 1921.

REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

President F. S. Kedzie,
Dear Sir:

There is evidence in abundance that we are far on the road to recovery from the war time spirit of unrest. The student work in this department has resumed much, if not all, of its antebellum seriousness and efficiency, and the staff is complete and competent. The lessons of hygiene and sanitation learned during the progress of the war have had an especially stimulating effect on the students' interest in the subjects taught in the department. The tabulations given below show clearly the amount and distribution of the class work for the year.

SUMMER TERM, 1920

Summer Term, 1920.

		Students
Bacteriology 1	Ward Giltner	27
Bacteriology 2	F. W. Fabian	10
Bacteriology 3	F. W. Fabian	1
Bacteriology 4	F. W. Fabian	1
Bacteriology 14	Ward Giltner	1

Fall Term, 1920.

Bacteriology 1	Ward Giltner	108
Bacteriology 1a	Ward Giltner	193
Bacteriology 2	W. L. Mallmann	23
Bacteriology 3	F. W. Fabian	20
Bacteriology 4	W. L. Mallmann	5
Bacteriology 13	Ward Giltner	16
Bacteriology 14	Ward Giltner	1
Bacteriology 24	F. W. Fabian	16

Winter Term, 1921.

Bacteriology 1b	Ward Giltner	153
Bacteriology 2	F. W. Fabian	73
Bacteriology 2	R. L. Tweed	10
Bacteriology 2	W. L. Mallmann	35
Bacteriology 3	F. W. Fabian	12
Bacteriology 4	W. L. Mallmann	7
Bacteriology 19	F. W. Fabian	1
Bacteriology 108	Ward Giltner	1

Spring Term, 1921.

Bacteriology 1c	Ward Giltner	149
Bacteriology 3	F. W. Fabian	14
Bacteriology 4	W. L. Mallmann	5
Bacteriology 13	Ward Giltner	1
Bacteriology 14	Ward Giltner	13
Bacteriology 15	Ward Giltner	2
Bacteriology 17	G. L. A. Ruehle	6
Bacteriology 19	I. F. Huddleson	18
Bacteriology 23	W. L. Mallmann	34
Bacteriology 105	R. L. Tweed	1
Bacteriology 108	R. L. Tweed	1

The influence of the new Applied Science course on the activities of the department cannot be estimated at this early date. There is already, as there has been for many years back, a considerable degree of interest manifest on the part of students who desire to take advantage of our exceptional facilities in an atmosphere of agricultural and technological education.

The department is in a strong position in respect to personnel and material equipment to undertake intensive and extensive instructional work in the fields of bacteriology and hygiene. However, for a number of years past we have not had sufficient funds to purchase much needed equipment and supplies, the lack of which has been prejudicial to the maximum productive effort.

May I urge that steps be taken to increase the appropriations for current expenses and equipment, so that we may be able not only to maintain the high standards of the past, but also to develop to a still higher plane. It is imperative that certain alterations be made in the building. Research laboratories to the rear of the lecture room should be utilized for class room space by enlarging the present lecture room and providing another smaller lecture room. We are required to seat over a hundred students in a room provided with only seventy-two seats. Furthermore, we have to undertake the accomodation of two or more classes at the same hour with only one classroom available. An animal room for small experimental animals should be and could be provided at slight expense between the main building and the stables.

I take pleasure in commending all those who have assisted in the teaching. Professors Fabian and Mallmann leave nothing to be desired in their conduct of the main student laboratory and the classes in general bacteriology. The former has progressed well in the development of a course in industrial hygiene, and a course in the bacteriology of the apiary; the latter has developed the great interest of the engineering students in sanitary bacteriology. Professor Ruehle has proved a well qualified teacher in dairy bacteriology, both of veterinary and agricultural students, and Mr Cooledge of graduate students. Mr. Tweed has demonstrated outstanding ability as an instructor in general bacteriology and as an inspiring director of advanced students. Mr. Friedemann has assisted in the student laboratory very satisfactorily. Professor Huddleson has had charge of the pathogenic bacteriology, serology and immunology and has acquitted himself with credit.

It is planned to release Mr. Huddleson from teaching hereafter and place Professor Stafseth in charge of this phase of the work. Leave of absence was extended Professor Stafseth till July 1st. Dr. Snyder had charge of the winter term short course students in agricultural bacteriology. He is an excellent teacher as demonstrated by his success with the class.

It is with no small measure of regret that I announce the retirement by

resignation of Mrs. Zae Northrup Wyant, at the close of the fiscal year. I shall take occasion to speak of her work in my report to the Director of the Experiment Station. When I took charge of the laboratory in 1912 she was engaged in research exclusively. Since then she has been under the necessity of teaching many classes under many circumstances. Without fail she has measured up to the responsibilities and with ability, energy and rare good nature she has proved what had already been demonstrated in the field of investigation, that in the students' laboratory she could command the respect of and stimulate and inspire all. Her capacity for work and versatility in a setting of rare good humor is without equal in my experience. She leaves a lasting impress on this institution and on the science of bacteriology.

I wish to thank you for your broad minded, generous and helpful cooperation throughout the year.

Respectfully,

WARD GILTNER,

Professor of Bacteriology and Hygiene.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF BOTANY.

President F. S. Kedzie,
East Lansing, Mich.

Dear Sir:

I have the honor to present to you the following report for the Department of Botany for the year closing June 30, 1921.

The departmental staff remained the same as for the preceding year with two minor changes as follows:

W. D. Mills was appointed to fill the half-time graduate assistantship which it had not been possible to fill the preceding year, and Miss Bertha A. Hollister, seed analyst, was appointed instructor for part time.

Although there was a marked increase in the number of students taking botany, as regards both required and elective courses, yet the number of both fall far short of that of previous years.

Of the four graduate students majoring in botany, two completed this work and received the degree of Master of Science with theses as follows:

Leo Joseph Klotz, A Study of the Celery Early Blight Fungus, *Cercospora apii* Fres.

Lionel Earl Tisdale, Bacterial Soft Rot of Lettuce.

In cooperation with the Michigan Geological and Biological Survey the study of the flora of the Upper Peninsula was continued, in particular that of Gogebic county, and of a portion of Baraga county. The results of the work in the summer of 1919 were published in the twenty-second report of the Michigan Academy of Science by Assistant Professor H. T. Darlington, under the title "Contributions to the Flora of Gogebic County, Michigan".

In continuation of the work of over six years on what is eventually to be published as a "Flora of Michigan", Professor Darlington has been working over the large family of grasses as they occur in the State, while Miss Thompson has been working on the violets of the State. These papers have not yet appeared in print.

Through the friendly cooperation of amateur and professional botanists, many additions have been made to the known flora of the State, and to the knowledge of the distribution of plants within the State borders.

At the meeting of the American Association for the Advancement of Science and affiliated societies at Chicago in December, the Department of Botany was represented by eight of its members, papers being presented by five. At the Michigan Academy of Science meeting in April, papers were presented by five from this department.

Respectfully submitted,
E. A. BESSEY,
Professor of Botany.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF CHEMISTRY.

President F. S. Kedzie,
East Lansing, Michigan.

Dear Sir:

I have the honor to submit the following report on the work of the Department of Chemistry for the year ending June 30, 1921.

The teaching staff for the year was as follows:

A. J. Clark, Professor.
R. C. Huston, Associate professor.
H. S. Reed, Associate professor.
B. E. Hartsuch, Associate professor.
D. T. Ewing, Assistant professor.
H. L. Publow, Assistant professor.
P. S. Brundage, Assistant professor.
C. D. Ball, Instructor.
E. F. Eldridge, Instructor.
H. C. Lange, Instructor.
H. D. Lightbody, Instructor.
W. C. Lewis, Instructor.
H. J. Walker, Instructor.
R. L. Baxter, Instructor.
H. M. Krebs, Instructor.

It has been very gratifying to have such an enthusiastic and loyal group of men on the staff. The success of the department is largely due to the fine spirit of cooperation shown by every member of the force. During the year Professor Ewing received the Ph.D. degree from the University of Chicago. A number of the other men in the department are pursuing graduate study at various universities, and I believe this is of great importance in keeping the department work on a high plane.

The department is working under two serious handicaps. First, the fact that the work of the department is scattered among four different buildings. To keep the department a well organized unit, under these conditions, is difficult. Second, with all the space made available by this scattering, we are obliged to place as high as three different lines of work in one laboratory.

There is great need of a new, modern, commodious, chemical laboratory building in order that the work in this science, which is fundamental to all the work of this College may be efficiently carried on.

Forty-nine courses have been offered during the year. The number of students enrolled in the department during the year is as follows:

Summer Term		1920	80
Fall	"	1920	610
Winter	"	1921	772
Spring	"	1921	622
Total			2984

Respectfully submitted,
ARTHUR J. CLARK,
Professor of Chemistry.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF HISTORY AND POLITICAL SCIENCE.

President F. S. Kedzie,
East Lansing, Michigan.

Dear Sir:

I hereby present a short report for the Department of History and Political Science. The courses of study for the year have been those of the past few years.

The department has presented a required course covering the history of Europe during the 19th century to freshmen women and a required course in contemporary European history to sophomore women. We continue to think that as a minimum requirement, these courses are well worth while for all college students.

Freshman engineers have been given a choice of courses in political science and 19th century history during the spring term. This arrangement is not altogether satisfactory since it concentrates the work in a single term. We believe students of this division should have opportunity sometime during the four years to get courses in history and political science.

The balance of the work in the department consists of junior and senior electives in the agricultural and home economics courses. The large elections in the face of the insistent demands of the technical and semi-technical subjects upon the time of the student, is a source of satisfaction to the department staff. The merits of this work, when properly taught in college, are, we believe, beyond question. In this attitude we are placing ourselves in accord with educational thought of the time.

Instruction has been given with two purposes in mind. One, that the work is an essential basis to any well-established superstructure in subjects involving social and economic aspects, in any large degree, and quite necessary to any well-rounded education. Second, that the key to the understanding of much of current doings in the world at any time, must be found in a correct understanding of the past. Guided by these two motives, we seek to avoid

confining the students' efforts to an accumulation of facts, merely; in fact, we assume the possession of such, as far as possible, through earlier training, and devote our attention to those interpretative features which, for the most part, establish a different conception of history for most students.

In the light of such considerations we view with hearty approval the tendencies in the College which point toward the greater opportunities for this training. The very liberal policies exhibited by the Home Economics and Agricultural divisions in the recent revision of courses are cases in hand, while the newly founded Applied Science course gives splendid recognition to the department by liberal terms, not alone in the acceptance of the already established courses but also the generous provisions for new courses. This seemingly is the tendency of training in these days—even in the highly technical institutions.

A few words as to the department staff. Mrs. Mary Hendrick continues her very efficient services as assistant professor. Mrs. Hendrick brings to the department her broad mature scholarship and exceptional teaching ability, and thereby becomes an indispensable asset to the department. In addition to the handling of a heavy classroom program, Mrs. Hendrick has responded to a large number of calls from women's clubs and other organizations for addresses upon current affairs. Had she the time at her disposal, a large service might be rendered in this capacity.

On account of the congestion of courses in the spring term, it has been necessary to supply additional help. For this purpose, Mr. Lu Willson of Jackson, has been employed during the spring and summer terms, during which time he has handled courses with credit to himself and satisfaction to the department.

All of which is respectfully submitted,

E. H. RYDER,
Professor of History and Political Science.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF ECONOMICS.

President F. S. Kedzie,
East Lansing, Michigan.

Dear Sir:

The following is the report of the Department of Economics for the academic year, 1920–'21.

The total number of enrollments in the department for the year equalled 860, distributed as follows:

By terms—Fall, 340; winter, 245; spring, 200; summer, 75.

By classes—Seniors, 185; juniors, 205; sophomores, 201; freshmen, 251; specials, 25.

By subjects—Economics, 755; sociology, 85.

The total number of hours taught during the year by members of the department equalled 1,305, divided as follows:

By terms—Fall, 411; winter, 372; spring, 312; summer, 210.

By subjects—Economics, 1,065; sociology, 240.

The department was insufficiently manned to take care of the number of

classes which the increasing post-war attendance put upon it. It is desired, therefore, to express very cordially our gratitude to Professor H. M. Eliot for his services in teaching a class each term of the year in economics.

The growing and well-deserved interest in marketing farm products has received due appreciation this year by the appointment of a specialist in this field of study as an associate in this department. Professor J. T. Horner, of Oklahoma, recently from Columbia University, was the selection of the State Board of Agriculture for this position. Professor Horner has had a long experience both in teaching and practicing marketing so that the department may consider itself fortunate in securing his services. Professor Dunford has given his usual loyal service to the College and to the department throughout the year.

Respectfully submitted,
WILBUR O. HEDRICK,
Professor of Economics.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF ENGLISH AND MODERN LANGUAGES.

President Frank S. Kedzie,
East Lansing, Michigan.

Dear Sir:

I have the honor to submit the following report upon the work of the Department of English and Modern Languages for the year ending June 30, 1921.

The table below shows in convenient form the number of students enrolled in the department during the year. It will be noted that Spanish was taught during only the winter and spring terms. Instruction in this language was added at the beginning of the winter term as a three-credit elective for senior engineers, and for juniors and seniors in the Division of Agriculture and in that of Home Economics.

TABLE.—*Student enrollment in the Department of English and Modern Languages.*

	English.	Spanish.	French.	Total.
Summer, 1920	89	....	6	95
Fall, 1920	794	....	55	849
Winter, 1921	871	44	50	965
Spring, 1921	626	30	40	696
Total	2,380	74	151	2,605

The teaching staff for the year was as follows:

W. W. Johnston, Professor of English and Modern Languages.
E. S. King, Associate Professor of Public Speaking.
Mrs. N. L. G. Roseboom, R. B. Weaver, Assistant Professors of English.
L. C. Hughes, O. M. Lebel, Assistant Professors of French.
P. R. Brees, Assistant Professor of Public Speaking.

L. B. Mayne, L. J. Davidson, A. H. Nelson, D. C. Limbaugh, G. S. Greene, Instructors in English.

F. E. Brown, Instructor in Public Speaking, (winter term).

Of the teaching staff named above three have been members of the department for but one year. These are Mr. Paul R. Brees, Mr. Guy S. Greene, and Mr. Denton C. Limbaugh.

I engaged Mr. Brees after Associate Professor C. B. Mitchell resigned in the summer of 1920 to accept the professorship of Public Speaking in the Oregon Agricultural College at a salary much larger than we were paying him. Mr. Brees received the degree of Bachelor of Arts from the University of Illinois in 1918. While in the university he was a member of two debate teams which defeated teams from the University of Iowa and the University of Michigan. Before coming to Michigan Agricultural College, Mr. Brees was head of the Department of Public Speaking in Friends University, of Wichita, Kansas, where his teams won the championship of the Kansas Intercollegiate Debate League. Mr. Brees has done high-grade work for us in every way.

Mr. Greene obtained his Bachelor's degree from Hobart College in the spring of 1920. I engaged him for an instructorship before his graduation, and immediately after receiving his degree he entered the graduate school of Cornell University in order that he might take, during the summer, work which would especially prepare him for teaching in the Michigan Agricultural College. He has proved himself to be a very valuable teacher.

Mr. Limbaugh, the third new man, has his Bachelor's degree from the Texas Christian University and his Master's degree from the University of Chicago.

Two members of this year's staff have resigned. Mr. Limbaugh will return to the University of Chicago to continue work for the degree of Ph.D. in English. Mr. L. J. Davidson, who came to M. A. C. from an instructorship in the State College of Pennsylvania, and who has been a member of the department for two years, resigns in order that he may take graduate work in English in the University of Michigan. He spent last summer in graduate work in the university, and he finds that in all probability he can obtain the degree of Ph.D. after one more year, as he now has the degree of Master of Arts from the University of Illinois and a similar degree from Harvard. It is with great regret that I lose Mr. Davidson. During his two years in Michigan Agricultural College he has won the favorable opinion of those who have come into contact with him. He is by nature and by training especially well adapted to the teaching profession, and is a young man of fine character and influence.

As in other years, I wish to report to you the outcome of the various contests conducted by the English department. The winner of the George E. Lawson Prize Essay Contest this year was Herman E. Segelin, a junior. The title of Mr. Segelin's essay is "Tennyson and Evolution." The essay is a thoughtful and well-written piece of work. It is the outgrowth of a special study of Tennyson which Mr. Segelin made in the summer of 1920 after having taken the course in Tennyson in the spring term of that year. This essay is printed in the commencement number of the M. A. C. record. The judges of the contest were Professor S. F. Gingerich of the University of Michigan, Thomas M. Johnson, and Milton Simpson, Professor of English in Kalamazoo College.

Both first and second prizes in the Eunomian-Holcad Contest were won this year by Miss Ruth Lechlitner. The first prize of $25, was awarded to her

for a poem entitled "The Factory" and the second prize, of $10, for a poem entitled "To The Wild Rose". I sent the poem winning the second prize to Contemporary Verse, and it was accepted for publication. Others who won prizes in this contest were Mr. Fred Henshaw and Mr. H. E. Laing. The judges of the contest were Dr. Dorothy Scarborough, who is a member of the faculty of Columbia University and who is well known as a poet and author of short stories, Howard Brubaker who is one of the best known short story writers of the United States, and John Muirhead, Professor of English in Hobart College.

The Lawson Contest and the Eunomian-Holcad Contest serve as valuable incentives to our students and have resulted in the production of some highly creditable essays, stories and poems. It will be recalled that a number of poems for the latter contest have been published in "Poets of the Future," an annual anthology published by the Stratford Company of Boston. It will be recalled also that R. S. Clark's winning poem, "Rime of the Plowman," was purchased by the American Magazine. Through a bequest left by Mr. George E. Lawson, the permanence of the Lawson Contest has been provided for. It would be an excellent thing for Michigan Agricultural College if friends of the institution would provide a fund which would insure the permanence of Eunomian-Holcad Contest. At present this contest is maintained only through appropriations made annually by the Eunomian Literary Society and the Holcad management.

This year, as has been our custom for seven years, we debated Iowa State College and Purdue University. For the first time in four years we lost our debates. The question for debate was, "Resolved, that the United States should adopt the cabinet-parliamentary system of government". The young men representing Michigan Agricultural College were Arthur Delamarter, Howard Chapel, H. K. Menhenick, Victor Whittemore, S. P. Nelson and J. B. Lazell. The first three constituted our affirmative team, which met Iowa State College upon our home platform. The last three supported the negative of the question and met Purdue's affirmative team at Lafayette. We lost each debate by a 2-1 decision. Although we were not victorious this year we have every reason to congratulate ourselves upon the work of our debaters. Each of our six men was making his first appearance in intercollegiate debate, and each acquitted himself well. Our men's analysis of the question was good and their presentation of the argument pleasing. Much credit is due to Professor Brees, who, as coach of the teams, prepared them for the contest. In connection with out forensic activities I am greatly pleased to inform you that Michigan Agricultural College has been granted a chapter of Pi Kappa Delta, a national fraternity of high standing.

Special mention should be made of the commencement play "Ingomar" given by the M. A. C. Dramatic Club under the direction of Associate Professor E. S. King. Almost a thousand people saw the performance, every seat being taken. The performance was of a high order of merit and reflects great credit upon Professor King and the Dramatic Club. The part of Ingomar was taken by Mr. D. V. Steere, that of Parthenia by Miss Mary Emily Ranney.

On the whole, the year just closing has been one of the best the department has ever known. Relative smallness of freshman sections has enabled us to do much better teaching. We have been able to see students improving steadily from week to week.

Among elective courses special mention should be made of Professor Weaver's work with senior engineers. These courses, given this year for the

first time, proved their worth so decisively that after the first three or four weeks the expected doubtful attitude of students changed to one of hearty appreciation. As I have considerable knowledge of the difficulties which teachers of English have to face in meeting junior and senior engineers in various institutions, I feel that in making a success of the work Professor Weaver has conclusively proved his ability to master difficult situations. This is all the more notable from the fact that he did not win his success by giving the engineers exactly what they wanted. Though a certain part of the work may be classed as "practical", he gave them, especially during the spring term, literature which would tend to lead them out into broad and vital human relations. He treated them not wholly as engineers or as men seeking to qualify for the largest possible salaries, but as citizens and as men. That students responded to this manner of approach is highly creditable to them as well as to their teacher.

In closing I wish to express my appreciation of the loyal, faithful and efficient work of the members of my department. I wish also to express genuine and hearty appreciation of the backing which your administration has given me. As I contemplate your retirement from the presidency of the College I do so with the grateful consciousness that in one respect in particular you have supported me without fail; by word and act you have stood behind me in my endeavor to obtain the best men for my department. In consequence, I can say that, in spite of the extreme and growing scarcity of good teachers of English, the personnel of the department has grown stronger year by year.

Very respectfully submitted,
W. W. JOHNSTON,
Professor of English and Modern Languages.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF MATHEMATICS.

President F. S. Kedzie,

Dear Sir:

I have the honor to submit for your consideration the following report on the work of the Department of Mathematics for the year ending June 30, 1921.

During the year the teaching staff of the department was as follows:

L. C. Plant, Professor.

L. C. Emmons, Associate professor.

G. G. Speeker, S. E. Crowe, V. G. Grove, T. O. Walton, F. E. Wood, assistant professors.

C. T. Bumer, W. H. Lyons, instructors.

Mr. T. O. Walton took up his work with us at the beginning of the fall term and Dr. F. E. Wood and Mr. W. H. Lyons came into residence at the beginning of the winter term.

During the year Professor Emmons has not only done his usual amount of teaching, but also has taken care of a large amount of statistical work that has been referred to him by different departments of the College.

The staff has continued its bi-weekly lectures on advanced work in mathe-

matics throughout the year. Other departments of the College, as well as the Department of Mathematics, have availed themselves of these lectures.

The total number of students taking mathematics during the year was 1,595, divided among the different terms as follows: Fall, 468; winter, 548; spring, 466; summer, 113. The total number of class periods for the year was 413, divided among the different terms as follows: Fall, 130; winter, 121; spring, 107; summer, 55.

Respectfully submitted,
L. C. PLANT.
Professor of Mathematics.

East Lansing, Michigan June 30, 1921.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

President F. S. Kedzie.

Dear Sir:

Following is a brief report of the work of the Department of Entomology for the year ending June 30, 1921.

During the year of 1920 and '21 one new instructor was taken into the department, Mr. I. C. Gentner, who comes here from the University of Wisconsin, where he served as special agent for the Federal Bureau of Entomology, working on truck-garden insects.

Mr. J. L. L. Frank has occupied the position of half-time graduate assistant, being assigned for the year to parasitology.

On August 1st the writer was given leave of absence until the following November for the purpose of collecting in Florida. During that time the work was in charge of Miss E. I. McDaniel, who ably carried on all the extra duties occasioned by the absence of the writer.

During the year the following courses were given:

Summer term 1920:

Ent. I—Introductory.
Ent. V—Classification of insects.

Fall term, 1920.

Ent. III—Field crop insects.
Ent. Va and b—Classification of insects.
Ent. VIII—Parasitology.
Ent. IXa—Apiculture, elective.
Ent. Xb—Apiculture, (option).
Ent. 100—Graduate work.
Ent. 101—Graduate work.

Winter term, 1921:

Ent. XII—Systematic entomology.
Ent. IV—Forest insects.
Ent. Xc—Apiculture (option).
Ent. XI—Household insects.
Ent. Va and b—Study of scale insects.
Ent. 100—Graduate work.
Ent. 101—Graduate work.

Short course poultry.
Short course fruit insects.
Short course apiculture for horticultural men.
Short course general entomology for men in general agriculture 16 weeks' course and 8 weeks' course.

Spring term, 1921:
Ent. I—Introductory entomology.
Ent. V—Systematic entomology.
Ent. Xa—Apiculture (option).
Ent. Xd—Apiculture (option).
Ent. IXb—Apiculture elective.
Ent. II—Fruit insects.
Ent. 100—Graduate work.
Ent. 101—Graduate work.

The reference collection is constantly absorbing time and effort in the attempt to increase its usefulness.

Many Federal Students are finding congenial work in the study of bees. Michigan Agricultural College enjoys a splendid reputation along this line.

The new State Department of Agriculture which has just been organized is taking over the State apiary inspection and relieving this department of further responsibility in the matter. Mr. B. F. Kindig, for several years, State inspector and instructor in the College goes to them. The work in the College will, however, be carried on in much the same manner by Mr. R. H. Kelty.

Respectfully submitted,
R. H. PETTIT,
Professor of Entomology.

East Lansing, Michigan June 30, 1921.

REPORT OF THE MILITARY DEPARTMENT.

The President, Michigan Agriculture College,
Dear Sir:

I have the honor to make the following brief report for the Department of Military Science for the year closing June 30, 1921.

I. EQUIPMENT.

This has gained little during the year as the War Department has issued practically all that the law permits. According to various inspectors who have visited us the past eight months, we are better equipped than most of the other institutions. The main lack is in motor transport, two trucks, a passenger car, and a motor cycle, for the work in coast artillery. Two trucks were borrowed from the Olds and the Reo on my own and Dr. Kedzie's request, for instruction during the latter part of the spring term. Pressure should be brought to bear through proper channels to secure from the War Department our authorized vehicles.

II. UNIFORMS.

These were in the main, very satisfactory, both in quality, fit and quantity. Unfortunately the spasm of economy has resulted in the elimination of shoes as an article of issue, a matter of great regret. The indications from Washington are that we will be compelled to re-issue to the students next year, especially the returned ones, the uniforms which they wore last year. The student will be obliged to have the uniform cleaned and pressed at his own expense in order that it may be presentable for every day wear.

III. THE UNITS.

Some friction developed in the cavalry unit during the year as two of the officers proved unsuited to their work and I was compelled to ask for their relief from duty. Major J. J. Teter has proven quite satisfactory since his arrival here in 1919 and Major Garr, just arrived in April, 1921, has taken hold in earnest. We are now in receipt of orders for two cavalry captains to report in August and another captain of infantry, is promised if obtainable. These extra officers enable us to have smaller classes and give more personal attention to the instruction of the individual. No annual inspection was made this year and therefore no report from Washington can be rendered. Personally, I believe that the work of the year has shown a distinct gain over the year before.

IV. THE ARMORY.

Floor space is inadequate and efforts should be made to obtain a suitable building, either through State appropriation or donation from some wealthy individual. We overflow into a basement room in the Gymnasium and have to call on the registrar for the assignment of rooms in other buildings, in which we cannot take or use the technical material of the department.

V. THE BUDGET.

Last year the State Board inadvertently omitted from their allowances the salary of our armorer-janitor. This important employee who had to be continued on the payroll and at $1,500,00 per year, caused our budget to show a deficiency of practically that amount on July 1st. Otherwise, we kept exactly within our allowances.

VI. EXTRANEOUS ACTIVITIES.

A. Rifle club. Membership this year ran close to 400, including men and women students, and faculty. The department bought and sold to the members, at cost, about 70,000 rounds of ammunition and expended about 120,000 rounds government, without cost. Medals, dinner and other prizes were awarded to winners. A sterling silver loving cup costing $105.00 was placed in contest among the fraternities to be won three years for permanent possession. The cup was taken this season by the Orphic Society.

B. Girls classes. Five classes of girls aggregating 90 members were organized by Miss Grimes in rifle firing during the winter term. Gold and silver medals were awarded winners.

C. Affiliation with the National Rifle Association was renewed last year, but while we fired the entire series of ten contests, no reports have ever been

published of the results. Next year we plan to award suitable sweaters to members of the N. R. A. team.

D. A theater party was held at the Bijou in the fall term with about 200 in attendance, at which performance the sponsors attended.

E. Sponsors were chosen early in the fall, one for corps and one for each unit. The purpose is to bring the young ladies into closer touch and greater sympathy with the Military department and to encourage them to use the advantages offered therein.

F. Dance. A corps dance was held the night of Washington's birthday at the Gymnasium. About 300 couple were present.

G. An annual field day was instituted, to be held close to the end of the spring term. Contests, partly military, partly athletic in character, of a nature that would be equal for all three units, were staged. The meet was won by the cavalry unit and a silk guidon presented to be carried by that unit at all formal functions until the next meet when they must defend their title.

VII. ATTENDANCE.

Attendance opened in the fall term with about 500 but owing to the liberal policy of the department in granting credits to the ex-service men, attendance dwindled rapidly, leaving us at the end of the year with 376 enrolled, receiving grades. The elective work carried with it 33 students. Next year's rolls show 56 new electives, making the junior and senior year students 86 strong who will be receiving commutation of rations. With the lessening of the numbers of ex-service men entering as freshmen, this department will pick up rapidly in size.

Respectfully submitted,
P. G. WRIGHTSON,
Major, U. S. A.

East Lansing, Michigan. June 30, 1921.

REPORT OF THE DEPARTMENT OF METEOROLOGY.

President F. S. Kedzie,
East Lansing, Michigan.

Dear President Kedzie:

I have the honor to report as follows regarding the work of the Department of Meteorology:

Twelve students enrolled for instruction in meteorology during the spring term, 1921. As usual the practical side of the subject was emphasized. Students were taught to carefully observe and correlate atmospheric conditions, each student making a complete record of weather conditions for one month from his own observations of temperature, pressure, wind velocity and direction, humidity, rainfall, clouds, etc. Instruction was given in forecasting from local conditions also with the aid of weather maps.

Unfortunately many students who would like to take the course in meteorology are prevented from doing so by conflicts with other subjects scheduled for the same hours one or more days in the week. Several came to me to see if some other hours could not be given to meteorology. Three to four or five

p. m. seems to be a time when more students are engaged in laboratory work or class recitations in required subjects than at other hours. From a study of the schedule it is thought that the hours from 10 to 11 a. m. or 12 noon might result in fewer conflicts if the course in Meteorology was changed to that time.

Very respectfully,

D. A. SEELEY,

Instructor in Meteorology.

East Lansing, Michigan, June 30, 1921.

METEOROLOGICAL TABLES.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, JULY, 1920.

Date.	Temperature.			Precipitation in inches.	Character of day.	Percentage of possible sunshine.
	Highest.	Lowest.	Mean.			
1	80	54	67	T.	Cloudy	54
2	87	63	75	0.05	Partly cloudy.	78
3	83	56	70	0	Clear	95
4	73	50	62	0	Partly cloudy	100
5	77	46	62	T.	Cloudy	64
6	74	63	68	0.24	Cloudy	2
7	68	57	62	T.	Cloudy.	0
8	75	55	65	0.60	Cloudy	11
9	78	58	68	0.03	Partly cloudy	77
10	83	54	68	0	Clear	97
11	80	57	68	0	Cloudy	28
12	84	57	70	0	Partly cloudy	68
13	88	66	77	0.23	Cloudy	52
14	77	56	66	0.16	Partly cloudy	47
15	79	52	66	0	Clear	100
16	73	46	60	0	Partly cloudy	87
17	79	48	64	0	Partly cloudy	59
18	78	58	68	1.40	Cloudy	28
19	78	54	66	0	Clear	100
20	79	52	66	0	Cloudy	72
21	85	63	74	T.	Cloudy	40
22	81	58	70	0	Clear	93
23	94	63	78	T.	Partly cloudy	49
24	75	57	66	T.	Cloudy	36
25	72	47	60	0	Partly cloudy	91
26	74	46	60	0	Partly cloudy	82
27	80	49	64	0	Clear	98
28	84	59	72	0.01	Cloudy	53
29	83	60	72	0.07	Cloudy	64
30	82	60	71	0.14	Cloudy	50
31	76	51	64	0.08	Cloudy	30

This month since 1863.		
Year.	Mean temperature.	Total precipitation.
1863		......
1864	74.5	1.25
1865	65.6	3.91
1866	71.7	4.19
1867	71.6	1.78
1868	77.2	1.11
1869	70.4	5.77
1870	74.4	8.02
1871	70.6	3.10
1872	71.9	3.36
1873	70.8	5.12
1874	72.0	2.56
1875	69.7	2.42
1876	72.5	2.10
1877	71.4	2.25
1878	73.0	2.96
1879	74.0	2.19
1880	68.0	6.27
1881	73.1	1.81
1882	67.5	2.32
1883	68.9	11.27
1884	68.0	2.60
1885	72.7	2.52
1886	70.7	0.65
1887	75.5	1.50
1888	70.5	2.40
1889	70.2	3.41
1890	71.1	0.92
1891	65.3	1.88
1892	70.3	2.00
1893	71.5	1.86
1894	73.2	0.86
1895	70.5	1.47
1896	71.8	6.73
1897	73.8	8.49
1898	70.0	1.34
1899	69.8	2.11
1900	69.6	4.15
1901	74.2	5.08
1902	70.6	7.13
1903	67.9	3.79
1904	69.2	1.97
1905	69.8	5.75
1906	70.8	2.23
1907	70.0	4.30
1908	73.2	1.03
1909	70.0	2.56
1910	71.0	1.53
1911	71.3	1.65
1912	69.6	5.06
1913	70.8	2.85
1914	71.0	1.65
1915	67.9	5.17
1916	76.1	0.09
1917	70.0	3.06
1918	69.2	1.96
1919	72.4	1.69
1920	67.3	3.01

Mean highest temperature	79.3
Mean lowest temperature	55.3
Mean temperature for month	67.3
Total precipitation for month	3.01

WEATHER.

Number days clear	6
Partly cloudy	10
Cloudy	15
With 0.01 or more of precipitation	11

SUNSHINE.

Number hours sunshine	285.6
Possible hours sunshine	464.9
Percentage of possible	61

BAROMETER—Mean, 29.98 inches; highest, 30.23 inches, on 26th; lowest, 29.56 inches, on 23rd.

TEMPERATURE—Highest, 94°, on 23rd; lowest, 46°, on 5th; greatest daily range, 31°, on 5th; least daily range, 11°, on 6th; normal for month, 70.9°; excess or deficiency this month,— 3.6°; accumulated excess or deficiency since January 1st, —585°; average daily, same period, —2.8°; highest in 35 years, 102°, lowest, 37°.

PRECIPITATION (in inches)—Total amount, 3.01; normal, 3.22; excess or deficiency this month, —0.21; since January 1st, —1.61; greatest amount in any 24 hour period, 1.40, on 18th; total snowfall, 0.0 in.

WIND—Prevailing direction, southwest; total movement, 3,364 miles; average hourly velocity, 4.5 miles; maximum velocity 19, from the southwest, on 29th.

DATES OF—Auroras, 0; hail, 0; thunderstorms, 2, 8, 13, 18, 21, 23, 29, 30; halos: solar, 10; lunar, 0; frost: killing, 0; heavy, 0; light, 0.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, AUGUST, 1920.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	66	46	56	0	Cloudy	41
2	71	43	57	0	Partly cloudy	85
3	78	46	62	0	Clear	99
4	81	51	66	0	Partly cloudy	76
5	86	61	74	T.	Partly cloudy	29
6	90	62	76	0.62	Partly cloudy	62
7	85	63	74	0	Partly cloudy	58
8	83	65	74	0	Partly cloudy	80
9	81	63	72	0.24	Cloudy	13
10	84	62	73	T.	Partly cloudy	79
11	86	59	72	0	Clear	100
12	89	62	76	0	Partly cloudy	72
13	80	66	73	0.48	Cloudy	11
14	78	63	70	0	Cloudy	19
15	83	61	72	0	Partly cloudy	66
16	72	63	68	0.15	Cloudy	0
17	85	57	71	0	Clear	98
18	86	54	70	0	Clear	95
19	85	56	70	0	Clear	96
20	86	67	76	0	Partly cloudy	36
21	76	54	65	0.33	Cloudy	0
22	66	44	55	0	Partly cloudy	57
23	74	43	58	0	Partly cloudy	76
24	76	46	61	0	Clear	100
25	78	45	62	0	Clear	100
26	79	49	64	T.	Partly cloudy	68
27	77	56	66	T.	Cloudy	10
28	80	58	69	0	Partly cloudy	41
29	76	60	68	0.18	Cloudy	20
30	83	57	70	0	Clear	100
31	75	55	65	0	Partly cloudy	36

Mean highest temperature ... 79.8
Mean lowest temperature ... 56.0
Mean temperature for month ... 67.9
Total precipitation for month ... 2.00

WEATHER.

Number days clear ... 8
Cloudy ... 8
Partly cloudy ... 15
With 0.01 or more of precipitation ... 6

SUNSHINE.

Number hours sunshine ... 253.6
Possible hours sunshine ... 430.7
Percentage of possible ... 59

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	3.00
1864	70.7	0.39
1865	65.8	3.38
1866	62.6	3.44
1867	69.8	1.74
1868	70.3	2.42
1869	70.6	4.85
1870	70.1	4.53
1871	71.2	1.42
1872	71.2	4.18
1873	69.5	0.80
1874	69.4	1.28
1875	65.5	1.47
1876	71.6	1.28
1877	68.5	6.57
1878	70.2	1.85
1879	70.0	1.61
1880	68.6	6.02
1881	72.7	1.63
1882	69.5	5.72
1883	64.9	0.18
1884	66.9	1.30
1885	63.6	6.75
1886	69.3	4.69
1887	68.0	0.89
1888	67.6	1.87
1889	68.6	0.68
1890	65.4	3.60
1891	67.9	4.82
1892	68.3	5.12
1893	68.1	0.56
1894	68.8	0.00
1895	71.2	4.64
1896	70.0	4.73
1897	65.9	1.69
1898	69.0	2.73
1899	71.4	0.70
1900	73.3	2.98
1901	68.4	2.49
1902	64.2	0.68
1903	64.3	6.73
1904	65.9	3.26
1905	69.6	3.92
1906	73.5	4.35
1907	65.5	2.87
1908	68.4	3.99
1909	71.0	1.61
1910	68.2	1.76
1911	68.2	1.48
1912	65.7	2.19
1913	69.4	5.60
1914	68.9	3.33
1915	63.4	4.63
1916	71.0	1.58
1917	67.0	1.47
1918	72.2	1.44
1919	67.3	4.03
1920	67.9	2.00

BAROMETER—Mean, 30.05 inches; highest, 30.32 inches, on 18th; lowest, 29.76 inches, on 29th.

TEMPERATURE—Highest, 90°, on 6th; lowest, 43°, on 2nd; greatest daily range, 33°, on 25th; least daily range, 9°, on 16th; normal for month, 68.4°; excess or deficiency this month, —0.5°; accumulated excess or deficiency since January 1st, —599°; average, daily, same period, —2.5°; highest in 35 years, 102°; lowest, 32°.

PRECIPITATION (in inches)—Total amount, 2.00; normal, 2.63; excess or deficiency this month, —0.63; since January 1st, —2.23 greatest amount in any 24 hour period, 0.62, on 6th; total snowfall, 0.0 in.

WIND—Prevailing direction, north; total movement, 2,525 miles; average hourly velocity, 3.4 miles; maximum velocity, 16, from the northwest, on 13th.

DATES OF—Auroras, 0; dense fog, 12, 15, 28, 29; thunderstorms, 6, 9, 10, 13, 20; halos: solar, 0; lunar, 0; frost: killing, 0; heavy, 0; light, 1.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, SEPTEMBER, 1920.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	74	46	60	0	Clear	98
2	72	42	57	0	Clear	100
3	73	39	56	0	Partly cloudy	80
4	75	43	59	0	Partly cloudy	63
5	67	53	60	0.02	Cloudy	0
6	74	52	63	0	Cloudy	32
7	78	50	64	0	Clear	100
8	80	47	64	0	Clear	98
9	75	60	68	0.05	Cloudy	5
10	76	59	68	0	Cloudy	12
11	80	59	70	T.	Cloudy	39
12	80	56	68	0	Clear	96
13	80	49	64	0	Clear	100
14	84	50	67	0	Clear	100
15	86	60	73	0.58	Cloudy	44
16	74	47	60	0	Clear	100
17	74	43	58	0	Clear	93
18	83	55	69	0	Partly cloudy	86
19	67	47	57	0	Partly cloudy	53
20	70	49	60	0.07	Cloudy	2
21	86	50	66	0	Partly cloudy	70
22	88	59	74	0	Partly cloudy	100
23	85	60	72	0	Clear	100
24	87	63	75	0.02	Clear	82
25	91	61	76	0	Clear	98
26	86	65	76	0.13	Partly cloudy	53
27	72	52	62	0.39	Cloudy	17
28	75	49	62	0	Clear	92
29	58	44	51	T.	Partly cloudy	14
30	53	37	45	T.	Cloudy	0
31						

Mean highest temperature	76.8
Mean lowest temperature	51.5
Mean temperature for month	64.2
Total precipitation for month	1.26

WEATHER.

Number days clear	13
Partly cloudy	8
Cloudy	9
With 0.01 or more of precipitation	7

SUNSHINE.

Number hours sunshine	241.6
Possible hours sunshine	374.8
Percentage of possible	64

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	0.89
1864	59.6	3.53
1865	67.7	4.79
1866	55.8	5.80
1867	56.6	1.42
1868	58.8	2.95
1869	63.5	1.43
1870	63.7	2.85
1871	59.1	0.79
1872	62.0	5.21
1873	67.4	3.50
1874	62.8	1.27
1875	58.5	2.89
1876	56.3	3.65
1877	61.3	1.38
1878	63.2	3.41
1879	56.2	3.19
1880	55.8	3.10
1881	69.7	2.91
1882	59.9	0.67
1883	56.4	2.34
1884	65.1	3.34
1885	58.9	3.75
1886	62.1	5.40
1887	58.9	4.72
1888	57.8	1.89
1889	61.2	0.79
1890	57.7	1.67
1891	65.1	1.10
1892	60.8	2.17
1893	58.4	1.84
1894	63.7	2.59
1895	66.6	0.85
1896	57.6	6.73
1897	62.9	0.80
1898	63.3	3.00
1899	57.0	2.14
1900	63.2	0.89
1901	61.7	1.67
1902	58.7	5.88
1903	61.0	2.86
1904	62.0	2.35
1905	63.8	3.21
1906	67.5	0.76
1907	61.8	4.68
1908	66.4	0.65
1909	60.4	1.51
1910	60.2	2.74
1911	61.5	5.05
1912	62.7	3.33
1913	61.0	1.53
1914	60.3	2.65
1915	63.2	6.55
1916	60.4	2.17
1917	58.6	4.60
1918	54.2	2.88
1919	63.8	2.61
1920	64.2	1.26

BAROMETER—Mean, 30.02 inches; highest, 30.34 inches, on 3rd; lowest, 29.68 inches, on 12th.

TEMPERATURE—Highest, 91°, on 25th; lowest, 37°, on 30th; greatest daily range, 36°, on 21st; least daily range, 14°, on 5th; normal for month, 61.6°; excess or deficiency this month, +2.6°; accumulated excess or deficiency since January 1st, —523°; average daily, same period,—1.9°; highest in 35 years, 99°, lowest, 21°.

PRECIPITATION (in inches)—Total amount, 1.26; normal, 2.62; excess or deficiency this month, —1.36; since January 1st, —3.59; greatest amount in any 24 hour period, 0.58, on 15th; total snowfall, 0.0 in.

WIND—Prevailing direction, south; total movement, 3,288 miles; average hourly velocity, 4.6 miles; maximum velocity, 22, from the southwest, on 28th.

DATES OF—Auroras, 7; dense fog, 0; thunderstorms, 9, 11, 15, 26, 27; halos: solar, 27; lunar, 22; frost: killing, 0; heavy, 30, light, 3.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, OCTOBER, 1920.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	56	37	46	0	Cloudy	25
2	64	37	50	0	Clear	82
3	73	50	62	0.02	Partly cloudy	65
4	72	47	60	0	Clear	100
5	63	38	50	0	Partly cloudy	93
6	68	35	52	0	Clear	100
7	71	36	54	0	Clear	100
8	73	43	58	0	Clear	98
9	79	47	63	0	Clear	100
10	77	42	60	0.01	Cloudy	73
11	78	51	64	0	Partly cloudy	62
12	81	49	65	0	Clear	82
13	81	57	69	0	Partly cloudy	88
14	81	56	68	0	Partly cloudy	88
15	82	57	70	0.01	Partly cloudy	86
16	66	54	60	0.01	Cloudy	19
17	68	50	59	0	Cloudy	52
18	73	50	62	0	Cloudy	50
19	82	56	69	0	Partly cloudy	81
20	82	58	70	0.01	Partly cloudy	78
21	82	57	70	0	Clear	99
22	82	54	68	0	Clear	100
23	81	53	67	0	Partly cloudy	77
24	64	50	57	0.08	Cloudy	9
25	58	45	52	0.11	Cloudy	18
26	61	45	53	0.59	Cloudy	0
27	57	41	49	0.47	Cloudy	0
28	47	32	40	0	Cloudy	21
29	42	28	35	T.	Cloudy	4
30	54	28	41	0	Clear	100
31	61	42	52	0.06	Cloudy	2

Mean highest temperature 69.6
Mean lowest temperature 46.0
Mean temperature for month 57.8
Total precipitation for month 1.37

WEATHER.

Number days clear 10
Partly cloudy 9
Cloudy 12
With 0.01 or more of precipitation 10

SUNSHINE.

Number hours sunshine 217.9
Possible hours sunshine 341.9
Percentage of possible 64

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	1.04
1864	45.7	1.86
1865	46.5	2.76
1866	49.5	3.57
1867	50.6	2.11
1868	45.2	1.11
1869	40.8	1.72
1870	52.5	2.29
1871	53.9	1.43
1872	47.4	0.67
1873	44.7	1.91
1874	49.1	0.49
1875	42.9	5.81
1876	43.7	1.26
1877	50.8	5.69
1878	48.3	1.99
1879	57.3	1.57
1880	46.2	2.84
1881	52.5	5.56
1882	52.7	2.64
1883	46.2	3.66
1884	50.9	5.73
1885	45.0	3.08
1886	52.4	0.95
1887	45.0	1.86
1888	45.7	3.00
1889	44.2	0.65
1890	49.1	4.56
1891	48.8	0.82
1892	48.3	0.78
1893	49.7	3.61
1894	49.8	1.91
1895	45.0	1.41
1896	44.6	1.06
1897	53.1	2.15
1898	49.6	3.55
1899	53.2	2.68
1900	56.6	2.77
1901	49.6	4.61
1902	49.6	1.53
1903	51.0	2.01
1904	48.6	1.90
1905	50.9	1.75
1906	49.2	2.36
1907	46.0	2.22
1908	51.6	0.82
1909	46.2	0.71
1910	51.8	2.27
1911	48.0	5.00
1912	50.4	3.44
1913	50.2	3.30
1914	54.6	2.81
1915	51.1	0.70
1916	49.7	2.53
1917	41.2	3.44
1918	52.6	3.21
1919	53.3	2.90
1920	57.8	1.37

BAROMETER—Mean, 30.09 inches; highest, 30.49 inches, on 6th; lowest, 29.40 inches, on 27th.

TEMPERATURE—Highest, 82°, on 22rd; lowest, 28°, on 30th; greatest daily range, 35°, on 7th; least daily range, 12°, on 6th; normal for month, 49.0°; excess or deficiency this month, +8.8°; accumulated excess or deficiency since January 1st, —248°; average daily, same period, —0.8°; highest in 35 years, 90°; lowest, 10°.

PRECIPITATION (in inches)—Total amount, 1.37; normal, 2.23; excess or deficiency this month, —0.86; since January 1st, —4.45; greatest amount in any 24 hour period, 0.63, on 25th and 26th; total snowfall, T.

WIND—Prevailing direction, southwest; total movement, 3,553 miles; average hourly velocity, 4.8 miles; maximum velocity 19, from the south, on 15th.

DATES OF—Auroras, 0; dense fog, 12, 17; thunderstorms, 10, 24, 27; halos: solar, 17, 18, 23; lunar, 0; frost: killing, 29; heavy, 6, 7; light, 2.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, NOVEMBER, 1920.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	54	43	48	0.35	Cloudy	0
2	54	32	43	0.21	Cloudy	0
3	48	33	40	0.01	Cloudy	29
4	57	33	45	0	Partly cloudy	76
5	54	33	44	0	Clear	93
6	49	31	40	T.	Cloudy	8
7	48	37	42	0.02	Cloudy	0
8	54	31	42	0.10	Partly cloudy	57
9	54	32	43	0.09	Cloudy	24
10	36	22	29	T.	Cloudy	17
11	32	18	25	T.	Cloudy	13
12	30	16	23	T.	Partly cloudy	67
13	27	22	24	T.	Cloudy	0
14	31	22	26	0.01	Cloudy	1
15	36	16	26	0.01	Cloudy	19
16	29	14	22	0.14	Cloudy	0
17	40	27	34	0.05	Cloudy	20
18	41	28	34	T.	Partly cloudy	31
19	49	29	39	0	Cloudy	0
20	54	35	44	0	Partly cloudy	49
21	51	42	46	0.19	Cloudy	0
22	47	37	42	0.79	Cloudy	0
23	40	37	38	0.03	Cloudy	0
24	39	37	38	0.14	Cloudy	0
25	39	33	36	0.02	Cloudy	0
26	33	30	32	0.06	Cloudy	0
27	38	27	32	T.	Cloudy	0
28	44	28	36	0	Partly cloudy	67
29	49	32	40	T.	Partly cloudy	63
30	46	37	42	0.07	Cloudy	1
31						

Mean highest temperature 43.4
Mean lowest temperature 29.8
Mean temperature for month 36.6
Total precipitation for month 2.29

WEATHER.

Number days clear 22
Partly cloudy 7
Cloudy 1
With 0.01 or more of precipitation 17

SUNSHINE.

Number hours sunshine 62.4
Possible hours sunshine 292.1
Percentage of possible 21

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	0.40
1864	37.9	4.12
1865	38.6	0.68
1866	37.9	2.60
1867	40.4	1.77
1868	36.8	2.44
1869	32.1	1.93
1870	38.4	0.91
1871	32.0	1.25
1872	29.8	0.98
1873	28.5	2.03
1874	35.0	1.61
1875	33.0	1.11
1876	36.3	0.91
1877	35.2	3.67
1878	36.3	2.16
1879	38.2	4.55
1880	27.5	2.32
1881	38.2	4.09
1882	36.3	1.83
1883	38.1	3.98
1884	34.1	1.84
1885	37.2	2.90
1886	33.9	1.48
1887	35.7	2.28
1888	38.5	3.12
1889	37.4	2.67
1890	39.1	2.30
1891	34.0	3.34
1892	34.2	1.84
1893	35.6	2.19
1894	32.5	0.97
1895	35.4	3.87
1896	37.1	1.05
1897	36.5	2.94
1898	33.1	2.72
1899	39.7	1.72
1900	35.3	5.10
1901	32.8	1.21
1902	43.0	2.46
1903	34.0	1.45
1904	40.0	0.04
1905	35.8	2.25
1906	37.0	2.66
1907	36.0	1.83
1908	38.2	1.82
1909	44.5	3.74
1910	34.0	1.37
1911	33.8	3.40
1912	38.6	2.86
1913	41.7	2.38
1914	37.6	1.40
1915	39.8	2.23
1916	38.8	1.68
1917	35.8	0.82
1918	40.4	3.22
1919	35.7	2.44
1920	36.6	2.29

BAROMETER—Mean, 30.10 inches; highest, 30.55 inches, on 6th; lowest, 29.55 inches, on 2nd.

TEMPERATURE—Highest, 57°, on 4th; lowest, 14°, on 16th; greatest daily range, 24°, on 4th; least daily range, 2°, on 24th; normal for month, 36.8°; excess or deficiency this month, —0.2°; accumulated excess or deficiency since January 1st,—257°; average daily, same period, —0.8°; highest in 35 years, 72°; lowest, 0°.

PRECIPITATION (in inches)—Total amount, 2.29; normal, 2.41; excess or deficiency this month, —0.12; since January 1st, —4.57; greatest amount in any 24 hour period, 0.79, on 22nd; total snowfall, 4.0.

WIND—Prevailing direction, southwest; total movement, 4,093 miles; average hourly velocity, 5.7 miles; maximum velocity, 25, from the southwest, on 9th.

DATES OF—Auroras, 0; dense fog, 0; sleet, 25; thunderstorms, 0; haloes, solar: 0; lunar, 17, 19, 20; frost: killing, —; heavy, —; light, —.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, DECEMBER, 1920.

Date.	Temperature. Highest.	Lowest.	Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	42	33	38	0.70	Cloudy	0
2	44	36	40	T.	Cloudy	23
3	55	36	46	0	Cloudy	40
4	51	35	43	0.81	Cloudy	0
5	42	31	36	0.03	Cloudy	0
6	44	31	38	0	Partly cloudy	49
7	38	26	32	0	Partly cloudy	46
8	38	25	32	0	Partly cloudy	75
9	40	28	34	0.06	Cloudy	7
10	35	32	34	0.16	Cloudy	0
11	38	32	35	0.01	Cloudy	0
12	53	35	44	0	Partly cloudy	46
13	56	48	52	0.27	Cloudy	0
14	53	28	40	0.34	Cloudy	2
15	30	25	28	0.08	Cloudy	0
16	29	24	26	T.	Cloudy	0
17	28	21	24	0.02	Cloudy	0
18	24	19	22	0.02	Cloudy	0
19	22	17	20	0.03	Cloudy	0
20	26	10	18	T.	Cloudy	9
21	31	11	22	0.18	Cloudy	0
22	43	33	38	0.80	Cloudy	0
23	38	22	30	0.06	Cloudy	0
24	22	15	18	0.02	Cloudy	19
25	21	14	18	T.	Cloudy	0
26	28	21	21	29	Cloudy	0
27	28	16	22	03	Cloudy	0
28	16	3	10	01	Cloudy	26
29	31	9	20	0	Cloudy	16
30	40	21	30	0.01	Partly cloudy	49
31	38	30	34	0.01	Cloudy	0

Mean highest temperature	36.4
Mean lowest temperature	24.7
Mean temperature for month	30.6
Total precipitation for month	3.94

WEATHER.

Number days clear	0
Partly cloudy	5
Cloudy	26
With 0.01 or more of precipitation	21

SUNSHINE.

Number hours sunshine	36.9
Possible hours sunshine	280.8
Percentage of possible	13

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	1.71
1864	24.4	3.20
1865	26.7	1.43
1866	25.5	1.90
1867	25.3	1.34
1868	21.2	1.35
1869	28.2	2.11
1870	24.8	2.57
1871	21.1	1.76
1872	15.7	1.06
1873	29.5	3.02
1874	27.0	0.37
1875	31.6	2.80
1876	15.2	1.29
1877	36.6	1.03
1878	21.3	2.27
1879	27.5	3.55
1880	22.1	0.85
1881	34.3	1.75
1882	24.8	0.88
1883	26.4	1.28
1884	24.7	4.15
1885	27.8	2.14
1886	19.7	1.56
1887	27.3	3.32
1888	30.4	1.20
1889	36.8	2.61
1890	26.4	1.12
1891	34.6	1.47
1892	25.6	1.52
1893	27.6	2.28
1894	30.1	0.93
1895	28.5	5.39
1896	28.1	0.80
1897	25.6	2.02
1898	24.8	1.42
1899	25.0	1.51
1900	26.7	0.50
1901	21.6	3.00
1902	24.8	2.89
1903	19.7	1.75
1904	21.7	1.42
1905	30.2	2.54
1906	26.8	1.85
1907	22.7	4.19
1908	26.4	2.08
1909	23.0	2.91
1910	21.6	1.28
1911	31.1	1.58
1912	31.0	1.20
1913	31.8	0.55
1914	21.6	1.57
1915	24.8	1.01
1916	22.7	2.11
1917	10.1	0.74
1918	32.9	3.61
1919	19.4	0.86
1920	30.6	3.94

BAROMETER—Mean, 29.90 inches; highest, 30.44 inches, on 21st; lowest, 29.00 inches, on 14th..

TEMPERATURE—Highest, 56°, on 13th; lowest, 3°, on 28th; greatest daily range, 25°, on 14th; least daily range, 3°, on 10th; normal for month, 26.8°; excess or deficiency this month, +3.8°; accumulated excess or deficiency since January 1st, —139°; average daily, same period, —0.4°; highest in 35 years, 62°; lowest, —24°.

PRECIPITATION (in inches)—Total amount, 3.94; normal, 2.08; excess or deficiency this month, +1.86; since January 1st, —2.71; greatest amount in any 24 hour period, 0.81, on 4th; total snowfall, 9.9.

WIND—Prevailing direction, west; total movement, 5,889 miles; average hourly velocity, 7.9 miles; maximum velocity 32, from the southwest, on 14th.

DATES OF—Auroras, 0; dense fog, 0; sleet, 30; thunderstorms, 0; halos: solar, 0; lunar, 0; frost: killing, —; heavy, —; light, —.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, JANUARY, 1921.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	49	33	41	0.10	Cloudy	0
2	36	29	32	T.	Cloudy	0
3	49	28	38	0	Clear	100
4	48	36	42	T.	Partly cloudy	44
5	38	29	34	0.03	Cloudy	0
6	37	29	33	0	Cloudy	26
7	45	34	40	0	Cloudy	5
8	40	20	30	0	Clear	100
9	34	17	26	0	Clear	100
10	42	23	32	0	Partly cloudy	98
11	35	20	28	T.	Partly cloudy	37
12	21	10	16	T.	Cloudy	11
13	24	10	17	0.03	Cloudy	3
14	28	22	25	0.03	Cloudy	0
15	29	20	24	0.02	Cloudy	5
16	31	17	24	0.02	Cloudy	3
17	20	7	14	T.	Cloudy	12
18	22	6	14	0	Partly cloudy	79
19	40	15	28	0.04	Cloudy	0
20	53	40	46	0.05	Cloudy	47
21	51	41	46	0.09	Cloudy	3
22	41	33	38	T.	Cloudy	0
23	39	26	32	0	Partly cloudy	93
24	29	12	20	T.	Cloudy	17
25	23	12	18	T.	Partly cloudy	31
26	30	12	21	T.	Clear	82
27	36	13	24	0	Partly cloudy	72
28	44	22	33	0	Partly cloudy	41
29	40	26	33	0	Cloudy	0
30	34	26	30	0	Cloudy	0
31	32	16	24	0	Partly cloudy	40

Mean highest temperature	36.2
Mean lowest temperature	22.1
Mean temperature for month	29.2
Total precipitation for month	0.41

WEATHER.

Number days clear	4
Partly cloudy	9
Cloudy	18
With 0.01 or more of precipitation	9

SUNSHINE.

Number hours sunshine	98.8
Possible hours sunshine	292.5
Percentage of possible	34

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	.....	.....
1864	22.3	0.91
1865	21.1	0.65
1866	21.2	2.03
1867	17.6	1.68
1868	19.0	1.47
1869	29.4	0.87
1870	25.4	1.93
1871	24.8	3.95
1872	21.6	0.42
1873	15.9	2.98
1874	27.7	3.53
1875	12.9	1.81
1876	30.2	1.63
1877	18.1	1.33
1878	29.1	1.12
1879	19.2	0.49
1880	37.1	2.67
1881	17.0	2.27
1882	24.9	1.47
1883	14.4	1.53
1884	15.5	1.23
1885	15.3	2.70
1886	18.8	2.66
1887	18.2	3.25
1888	15.4	2.18
1889	28.0	1.53
1890	31.5	2.31
1891	26.7	0.82
1892	19.2	0.96
1893	14.8	1.78
1894	26.9	1.37
1895	17.5	1.04
1896	24.6	0.79
1897	22.3	4.17
1898	24.9	3.07
1899	21.7	2.03
1900	25.6	1.17
1901	22.2	1.51
1902	20.5	0.43
1903	20.7	1.20
1904	14.4	2.82
1905	18.2	1.07
1906	31.8	1.99
1907	23.2	3.97
1908	23.8	1.89
1909	26.6	2.16
1910	23.4	2.52
1911	25.2	1.43
1912	9.2	0.80
1913	26.2	3.10
1914	27.0	2.98
1915	20.4	1.54
1916	27.6	3.11
1917	21.0	1.55
1918	10.2	2.08
1919	28.5	0.36
1920	13.2	1.34
1921	29.2	0.41

BAROMETER—Mean, 30.13 inches; highest, 30.96 inches, on 18th; lowest, 29.45 inches, on 1st.

TEMPERATURE—Highest, 53°, on 20th; lowest, 6°, on 18th; greatest daily range, 25°, on 19th; least daily range, 6°, on 14th; normal for month, 22.7°; excess or deficiency this month, +6.4°; accumulated excess or deficiency since January 1st, +200°; average daily, same period, +6.4°; highest in 36 years, 63°, lowest, —26°.

PRECIPITATION (in inches)—Total amount, 0.41; normal, 2.09; excess or deficiency this month, —1.68; since January 1st, —1.68; greatest amount in any 24 hour period, 0.14, on 20th and 21st; total snowfall, 1.7.

WIND—Prevailing direction, southwest; total movement, 5,902 miles; average hourly velocity, 7.9 miles; maximum velocity, 30, from the northwest, on 16th.

DATES OF—Auroras, 0; dense fog, 0; sleet, 19; thunderstorms, 0; halos: solar, 10, 13, 27, 29; lunar, 19; frost: killing, —; heavy, —; light, —.

DEWEY A. SEELEY,
Meteorologist

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, FEBRUARY, 1921.

Date.	Temperature. Highest.	Lowest.	Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	31	11	21	0.01	Cloudy	38
2	30	25	28	0.01	Cloudy	0
3	30	22	26	0.01	Cloudy	8
4	37	24	30	0.10	Cloudy	0
5	38	32	35	0	Cloudy	3
6	35	25	30	0.03	Partly cloudy	78
7	32	26	29	0.10	Cloudy	0
8	34	26	30	0.05	Cloudy	44
9	35	32	34	T.	Cloudy	0
10	32	30	31	0.01	Cloudy	0
11	31	23	27	0.02	Cloudy	22
12	36	21	28	T.	Cloudy	2
13	37	29	33	0	Cloudy	0
14	38	25	32	0	Clear	92
15	56	25	40	0	Partly cloudy	88
16	59	28	44	T.	Partly cloudy	59
17	28	16	22	0.01	Cloudy	1
18	31	11	22	T.	Clear	89
19	28	16	22	T.	Cloudy	19
20	30	12	21	T.	Partly cloudy	59
21	36	15	26	0	Cloudy	93
22	45	18	32	0.09	Cloudy	56
23	33	17	25	0.02	Cloudy	7
24	26	9	18	0	Partly cloudy	66
25	30	20	25	0.07	Cloudy	34
26	31	20	26	0.69	Cloudy	0
27	30	20	25	0	Cloudy	5
28	36	29	32	T.	Cloudy	0
29						
30						
31						

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	....
1864	27.3	0.27
1865	27.6	1.76
1866	22.7	2.28
1867	30.9	3.23
1868	18.7	1.28
1869	26.7	2.95
1870	24.2	1.20
1871	25.6	1.73
1872	21.3	0.46
1873	19.1	0.77
1874	25.5	1.55
1875	8.0	2.20
1876	27.4	3.01
1877	32.3	0.00
1878	28.1	2.71
1879	20.4	1.43
1880	29.2	1.62
1881	21.6	3.77
1882	36.1	2.28
1883	19.8	4.50
1884	23.4	3.69
1885	8.9	0.73
1886	22.3	1.35
1887	24.3	5.71
1888	22.0	1.70
1889	18.3	1.17
1890	31.5	1.79
1891	26.7	2.20
1892	27.3	1.93
1893	21.3	1.83
1894	21.2	0.53
1895	16.4	0.12
1896	24.3	1.51
1897	26.4	0.67
1898	23.8	1.82
1899	16.8	1.51
1900	17.4	3.44
1901	12.8	1.83
1902	18.6	0.44
1903	20.6	1.58
1904	12.0	3.30
1905	15.8	1.25
1906	23.6	1.12
1907	19.2	0.25
1908	21.6	3.19
1909	28.4	2.36
1910	21.9	2.65
1911	27.6	1.77
1912	15.8	2.04
1913	20.0	1.65
1914	12.7	0.79
1915	29.4	2.10
1916	19.2	0.69
1917	15.5	0.62
1918	21.8	3.04
1919	27.0	1.50
1920	19.8	0.81
1921	28.3	1.25

Mean highest temperature 34.8
Mean lowest temperature 21.8
Mean temperature for month 28.3
Total precipitation for month 1.25

WEATHER.

Number days clear 2
Partly cloudy 5
Cloudy 21
With 0.01 or more of precipitation 14

SUNSHINE.

Number hours sunshine 91.6
Possible hours sunshine 295.2
Percentage of possible 31

BAROMETER—Mean, 30.01 inches; highest, 30.58 inches, on 19th; lowest, 29.57 inches, on 16th.

TEMPERATURE—Highest, 59°, on 16th; lowest, 9°, on 24th; greatest daily range, 31°, on 15th; least daily range, 2°, on 10th; normal for month, 21.6°; excess or deficiency this month, +6.7°; accumulated excess or deficiency since January 1st, +389°; average daily, same period, +6.6°; highest in 36 years, 62°, lowest, —25°.

PRECIPITATION (in inches)—Total amount, 1.25; normal, 2.02; excess or deficiency this month, —0.77; since January 1st, —2.45; greatest amount in any 24 hour period, 0.74, on 25th and 26th; total snowfall, 10.9.

WIND—Prevailing direction, west; total movement, 4.661 miles; average hourly velocity, 6.9 miles; maximum velocity, 25, from the west, on 16th.

DATES OF—Auroras, 0; dense fog, 0; sleet, 0; thunderstorms, 0; halos: solar, 15, 19, 21, 22; lunar, 21; frost: killing, —; heavy, —; light, —.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, MARCH, 1921.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	42	33	38	0.03	Cloudy	9
2	53	37	45	T.	Clear	99
3	39	16	28	0.01	Cloudy	2
4	31	15	23	0.17	Cloudy	0
5	54	31	42	0.18	Cloudy	23
6	54	33	44	0.02	Cloudy	0
7	44	32	38	T.	Cloudy	21
8	55	32	44	0.63	Cloudy	0
9	40	23	32	T.	Cloudy	39
10	53	22	38	0	Clear	100
11	61	32	46	0	Partly cloudy	89
12	54	35	44	0.46	Cloudy	4
13	38	31	31	0.01	Cloudy	0
14	40	31	36	0.06	Cloudy	0
15	66	38	52	T.	Cloudy	32
16	48	30	39	0	Clear	100
17	49	29	39	0.17	Cloudy	18
18	45	24	34	0	Cloudy	40
19	76	35	56	0	Partly cloudy	79
20	75	51	63	0.74	Cloudy	18
21	51	30	40	0.02	Cloudy	10
22	32	25	28	T.	Cloudy	0
23	50	25	38	0	Partly cloudy	89
24	54	36	45	0.40	Cloudy	0
25	55	41	48	0.16	Cloudy	25
26	66	42	54	0.12	Cloudy	60
27	67	38	52	0.16	Cloudy	8
28	38	17	28	T.	Cloudy	11
29	39	13	26	0	Clear	100
30	57	28	42	0	Clear	97
31	48	26	37	T.	Cloudy	22

Mean highest temperature 50.8
Mean lowest temperature 30.0
Mean temperature for month 40.4
Total precipitation for month 3.34

Weather.

Number days clear 5
Partly cloudy 3
Cloudy 23
With 0.01 or more of precipitation 16

Sunshine.

Number hours sunshine 131.6
Possible hours sunshine 370.5
Percentage of possible 36

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863	....	....
1864	31.7	2.26
1865	37.0	2.79
1866	29.1	3.39
1867	29.7	0.68
1868	37.8	4.65
1869	27.6	1.65
1870	30.3	3.01
1871	38.2	3.91
1872	24.8	2.04
1873	28.3	1.73
1874	32.3	1.79
1875	26.2	1.02
1876	30.6	4.81
1877	24.5	5.60
1878	40.9	3.12
1879	33.2	1.57
1880	35.5	1.70
1881	30.3	2.66
1882	36.0	3.58
1883	24.9	0.71
1884	29.9	3.67
1885	21.3	0.58
1886	31.3	2.63
1887	28.3	1.78
1888	27.0	1.88
1889	37.6	1.22
1890	28.2	1.54
1891	29.3	2.41
1892	29.9	1.31
1893	28.2	2.82
1894	40.1	1.25
1895	27.2	0.27
1896	28.7	1.31
1897	33.0	2.08
1898	37.0	3.59
1899	26.3	3.30
1900	23.6	1.88
1901	31.1	2.94
1902	38.0	3.16
1903	41.0	1.25
1904	30.2	3.45
1905	35.4	3.15
1906	26.2	1.86
1907	38.6	2.84
1908	34.8	2.19
1909	29.9	0.90
1910	44.0	0.40
1911	32.7	1.21
1912	22.4	1.92
1913	31.0	3.76
1914	31.1	1.52
1915	30.1	0.78
1916	26.2	3.09
1917	34.6	2.88
1918	37.1	3.58
1919	33.8	3.48
1920	35.2	3.57
1921	40.4	3.34

BAROMETER—Mean, 30.05 inches; highest, 30.77 inches, on 22nd; lowest, 29.38 inches, on 24th.

TEMPERATURE—Highest, 76°, on 19th; lowest, 13°, on 29th; greatest daily range, 41°, on 19th; least daily range, 7°, on 13th; normal for month, 32.3°; excess or deficiency this month, +8.1°; accumulated excess or deficiency since January 1st, +639°; average daily, same period, +7.1°; highest in 36 years, 82°; lowest, −12°.

PRECIPITATION (in inches)—Total amount, 3.34; normal, 2.26; excess or deficiency this month, +1.08; since January 1st, −1.37; greatest amount in any 24 hour period, 0.76, on 20th and 21st; total snowfall, 2.1.

WIND—Prevailing direction, southwest; total movement, 6,101 miles; average hourly velocity, 8.2 miles; maximum velocity 28, from the southwest, on 20th.

DATES OF—Auroras, 0; dense fog, 26; thunderstorms, 5, 7, 20, 26, 27; halos: solar, 1, 9, 11, 15, 16, 18, 19, 26. lunar, 0; frost: killing, —; heavy, —; light, —.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, APRIL, 1921.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	48	19	34	0	Clear	100
2	68	40	54	0	Partly cloudy	100
3	76	43	60	0	Partly cloudy	100
4	77	49	63	0	Partly cloudy	100
5	79	51	65	0	Clear	100
6	81	49	65	0	Clear	99
7	75	54	64	0.10	Cloudy	35
8	62	40	51	0.52	Cloudy	9
9	45	31	38	0.26	Cloudy	15
10	40	25	32	0.02	Partly cloudy	53
11	54	25	40	0	Clear	100
12	59	38	48	0	Cloudy	35
13	53	45	49	0.18	Cloudy	0
14	56	43	50	0.25	Cloudy	2
15	53	38	46	T.	Cloudy	0
16	38	28	33	0.66	Cloudy	0
17	34	26	30	0.22	Cloudy	0
18	57	25	41	0	Clear	100
19	67	34	50	0	Clear	98
20	73	44	58	0	Partly cloudy	61
21	72	53	62	0.20	Cloudy	33
22	59	54	56	0.44	Cloudy	0
23	54	45	50	0.12	Cloudy	17
24	79	47	63	T.	Clear	91
25	82	62	72	0.06	Cloudy	42
26	76	61	68	0.39	Cloudy	45
27	65	46	56	0.19	Cloudy	20
28	65	44	54	0.13	Partly cloudy	58
29	49	43	46	0.06	Cloudy	0
30	59	38	48	0	Clear	100
31						

Mean highest temperature	61.8
Mean lowest temperature	41.3
Mean temperature for month	51.6
Total precipitation for month	3.80

WEATHER.

Number days clear	8
Partly cloudy	6
Cloudy	16
With 0.01 inch or more of precipitation	16

SUNSHINE.

Number hours sunshine	201.7
Possible hours sunshine	402.5
Percentage of possible	50

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863		
1864	45.9	3.80
1865	47.4	2.32
1866	48.9	1.40
1867	48.2	2.19
1868	43.7	1.83
1869	45.7	3.42
1870	50.4	2.02
1871	49.8	2.97
1872	47.4	1.26
1873	43.2	3.88
1874	36.9	1.67
1875	41.1	0.61
1876	44.2	2.08
1877	46.2	4.14
1878	50.6	3.76
1879	44.8	1.25
1880	45.9	7.06
1881	45.6	1.73
1882	44.7	1.88
1883	43.5	1.90
1884	43.7	1.95
1885	43.6	2.47
1886	50.2	1.99
1887	45.4	0.90
1888	44.0	1.15
1889	46.6	2.02
1890	47.2	3.20
1891	47.4	1.74
1892	44.5	2.04
1893	43.5	4.81
1894	48.4	2.76
1895	48.6	0.67
1896	52.6	2.77
1897	44.6	2.74
1898	43.6	2.12
1899	49.8	1.23
1900	47.4	2.00
1901	46.4	2.16
1902	44.6	1.70
1903	43.0	4.40
1904	39.4	0.50
1905	44.6	1.49
1906	46.6	2.43
1907	37.8	2.81
1908	44.6	2.15
1909	42.8	5.96
1910	49.2	2.48
1911	44.3	2.11
1912	45.6	3.12
1913	45.9	3.10
1914	44.7	2.90
1915	51.6	1.00
1916	45.7	1.91
1917	42.4	5.59
1918	42.4	1.97
1919	44.8	4.13
1920	39.9	3.25
1921	51.6	3.80

BAROMETER—Mean, 29.99 inches; highest, 30.42 inches, on 11; lowest, 29.33 inches, on 23.

TEMPERATURE—Highest, 81°, on 6; lowest, 19°, on 1; greatest daily range 33°, on 3; least daily range, 5°, on 22; normal temperature, 45.6°; departure, +6.0°; accumulated departure since January 1, +818°; average daily departure since January 1, +6.8°; highest in 36 years, 88°; lowest, 10°.

PRECIPITATION (in inches)—Total this month, 3.80; normal, 2.54; departure, +1.26; since January 1st, —0.11; greatest amount in 24 hours, 0.66, on 16; total snowfall, 4.2 in.

WIND—Prevailing direction, southwest; total movement, 5,544 miles; average hourly velocity, 7.7 miles; maximum velocity, 27 miles per hour, from south west, on 27.

DATES OF—Auroras, 0; hail, 0; sleet, 16; fog, dense, 0; thunderstorms, 8, 21, 22, 25, 26, 28; halos, solar: 1, 2, 3, 4, 5, 20, 24, 28; lunar, 0; frost: killing, 11, 18; heavy, 0; light, 9, 19.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, MAY, 1921.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
....	....	....	....	....	....	....
1	59	33	46	0	Partly cloudy	76
2	42	36	39	0	Cloudy	0
3	51	37	44	0	Cloudy	20
4	65	40	52	0	Partly cloudy	94
5	71	46	58	0	Clear	100
6	70	43	56	T.	Cloudy	41
7	70	42	56	0	Clear	99
8	72	39	56	0	Clear	100
9	76	42	59	0	Clear	100
10	78	46	62	0	Partly cloudy	81
11	72	49	60	T.	Partly cloudy	72
12	68	53	60	0.02	Cloudy	6
13	65	49	57	0.03	Partly cloudy	49
14	49	41	45	T.	Cloudy	1
15	52	33	42	0	Partly cloudy	61
16	60	30	45	0	Clear	99
17	65	34	50	T.	Cloudy	63
18	64	51	58	0.07	Cloudy	20
19	84	51	68	0	Clear	86
20	88	58	73	0	Clear	100
21	89	63	76	0	Partly cloudy	84
22	87	64	76	0	Partly cloudy	98
23	85	60	72	0.28	Partly cloudy	77
24	81	58	70	0.57	Cloudy	35
25	82	59	70	0	Clear	79
26	76	55	66	0	Partly cloudy	92
27	81	56	68	0.33	Cloudy	35
28	75	63	69	0.01	Cloudy	45
29	86	59	72	0	Clear	81
30	87	60	74	0	Clear	99
31	81	60	70	0.02	Cloudy	59

This month since 1863. Year.	Mean temperature.	Total precipitation.
1863	....	....
1864	60.2	2.87
1865	57.6	1.77
1866	55.0	3.48
1867	61.1	3.80
1868	59.1	2.80
1869	56.0	2.05
1870	64.3	1.16
1871	61.4	1.97
1872	58.5	3.72
1873	56.9	3.05
1874	59.6	1.77
1875	60.8	4.46
1876	58.0	4.13
1877	58.2	2.23
1878	54.6	3.44
1879	58.8	2.45
1880	64.3	5.59
1881	65.2	2.11
1882	52.7	4.04
1883	52.8	5.66
1884	56.9	3.95
1885	55.8	2.30
1886	58.1	2.67
1887	61.3	2.42
1888	53.7	3.66
1889	57.4	3.61
1890	53.7	4.98
1891	55.7	1.63
1892	54.5	5.92
1893	54.4	2.86
1894	56.9	4.83
1895	61.8	2.06
1896	66.5	3.14
1897	55.8	3.29
1898	56.5	2.15
1899	58.8	3.59
1900	58.8	4.17
1901	55.2	2.42
1902	58.4	4.92
1903	59.5	2.63
1904	57.4	2.40
1905	56.7	5.17
1906	56.6	3.05
1907	51.2	2.22
1908	59.6	5.59
1909	55.8	2.44
1910	51.5	4.13
1911	63.5	2.67
1912	57.6	6.57
1913	56.2	2.22
1914	58.6	4.66
1915	51.5	2.74
1916	56.6	5.13
1917	50.2	3.37
1918	61.1	2.89
1919	54.5	4.29
1920	55.1	1.43
1921	60.4	1.33

Mean highest temperature	72.0
Mean lowest temperature	48.7
Mean temperature for month	60.4
Total precipitation for month	1.33

WEATHER.

Number days clear	10
Partly cloudy	10
Cloudy	11
With 0.01 inch or more of precipitation	8

SUNSHINE.

Number hours sunshine	301.0
Possible hours sunshine	454.7
Percentage of possible	66

BAROMETER—Mean, 30.02 inches; highest, 30.34 inches, on 16; lowest, 29.74 inches, on 13.

TEMPERATURE—Highest, 89°, on 21; lowest, 30°, on 16; greatest daily range, 34°, on 9; least daily range, 6° on 2; normal temperature, 57.1°; departure, +3.3°; accumulated departure since January 1, +918°; average daily departure since January 1, +6.1°; highest in 36 years, 95°; lowest, 17°.

PRECIPITATION (in inches)—Total this month, 1.33; normal, 3.58; departure, —2.25; since January 1st,—2.36; greatest amount in 24 hours, 0.85, on 23 and 24; total snowfall, 0.0 in.

WIND—Prevailing direction west; total movement, 4,342 miles; average hourly velocity, 5.8 miles; maximum velocity, 20 miles per hour from northwest, on 13.

DATES OF—Auroras, 13, 15, 16; hail, 0; sleet, 0; fog, dense, 0; thunderstorms, 23, 24, 27, 30, 31; halos: solar, 4, 17, 23, 24. lunar, 0; frost: killing, 16; heavy, 0; light, 1, 15, 17.

DEWEY A. SEELEY,
Meteorologist.

MONTHLY METEOROLOGICAL SUMMARY, LANSING, MICHIGAN, JUNE, 1921.

Date.	Temperature. Highest.	Temperature. Lowest.	Temperature. Mean.	Precipitation in inches.	Character of day.	Percentage of possible sunshine.
1	74	52	63	0	Partly cloudy	87
2	84	52	68	0.10	Cloudy	65
3	75	44	60	T.	Partly cloudy	49
4	65	39	52	0	Clear	100
5	70	37	54	0	Clear	85
6	74	42	58	T.	Partly cloudy	78
7	65	56	60	0.02	Cloudy	5
8	77	57	67	0.03	Partly cloudy	44
9	84	56	70	0	Partly cloudy	100
10	89	65	77	0.07	Partly cloudy	68
11	82	63	72	0.03	Partly cloudy	49
12	86	54	70	0	Clear	100
13	85	60	72	0	Clear	99
14	82	54	68	0	Partly cloudy	76
15	84	55	70	0	Clear	88
16	84	64	74	T.	Partly cloudy	54
17	94	65	80	0	Clear	100
18	90	65	78	1.12	Cloudy	47
19	83	60	72	0	Clear	100
20	87	54	70	0.09	Clear	92
21	90	65	78	0	Partly cloudy	66
22	88	67	78	0	Partly cloudy	86
23	87	66	76	0	Partly cloudy	88
24	87	62	74	0	Partly cloudy	76
25	89	62	76	0.04	Partly cloudy	77
26	89	65	77	0.07	Partly cloudy	66
27	84	67	76	1.02	Cloudy	27
28	80	67	74	0.65	Cloudy	24
29	87	66	76	0	Clear	100
30	91	64	78	0	Clear	97
31						

Mean highest temperature	82.9
Mean lowest temperature	58.2
Mean temperature for month	70.6
Total precipitation for month	3.24

WEATHER.

Number days clear	10
Partly cloudy	15
Cloudy	5
With 0.01 inch or more of precipitation	11

SUNSHINE.

Number hours sunshine	335.0
Possible hours sunshine	459.4
Percentage of possible	73

This month since 1863.

Year.	Mean temperature.	Total precipitation.
1863		3.88
1864	67.6	3.55
1865	70.8	5.37
1866	66.6	2.83
1867	71.6	3.55
1868	68.5	4.40
1869	64.4	7.27
1870	70.9	2.93
1871	68.2	3.45
1872	71.8	2.96
1873	70.6	5.07
1874	70.6	1.84
1875	66.6	4.34
1876	68.1	3.53
1877	65.9	3.15
1878	64.1	2.87
1879	66.0	5.04
1880	67.6	4.37
1881	64.3	5.57
1882	66.5	11.35
1883	65.9	2.83
1884	68.9	6.01
1885	64.7	1.92
1886	65.7	2.47
1887	68.5	2.51
1888	67.9	3.42
1889	62.8	3.92
1890	70.3	2.55
1891	67.4	4.33
1892	67.7	4.85
1893	66.6	1.30
1894	71.4	1.01
1895	71.4	2.60
1896	69.9	2.57
1897	64.2	4.91
1898	67.6	1.15
1899	68.2	2.57
1900	65.2	3.57
1901	68.0	7.28
1902	61.8	6.28
1903	62.0	2.49
1904	65.6	7.47
1905	66.2	4.61
1906	67.1	2.37
1907	65.0	1.23
1908	70.0	2.86
1909	66.7	1.95
1910	64.9	3.77
1911	68.0	0.97
1912	63.1	1.01
1913	67.6	4.11
1914	66.0	3.96
1915	61.0	5.39
1916	61.4	4.54
1917	62.4	2.07
1918	64.4	3.18
1919	71.9	4.17
1920	67.7	3.24
1921	70.6	

BAROMETER—Mean, 29.98 inches; highest, 30.44 inches, on 5; lowest, 29.66 inches, on 28.

TEMPERATURE—Highest, 94°, on 17; lowest, 37°, on 5; greatest daily range, 33°, on 20; least daily range, 9°, on 7; normal temperature, 67.2°; departure, +3.4°; accumulated departure since January 1, +1021°; average daily departure since January 1, +5.6°; highest in 36 years, 99°; lowest, 34°.

PRECIPITATION (in inches)—Total this month, 3.24; normal, 3.40; departure, —0.16; since January 1st, —2.52; greatest amount in 24 hours, 1.63, on 27 and 28; total snowfall, 0.0 in.

WIND—Prevailing direction, south; total movement, 2,903 miles; average hourly velocity, 4.0 miles; maximum velocity, 18 miles per hour, from southwest, on 18.

DATES OF—Auroras, 0; hail, 0; sleet, 0; fog, dense, 0; thunderstorms, 2, 10, 18, 20, 21, 25, 26, 27, 28; halos: solar, 2, 5, 6, 7, 14, 23, lunar, 0; frost: killing, 0; heavy, 0; light, 4, 5.

DEWEY A. SEELEY,
Meteorologist.

REPORT OF THE PHYSICS DEPARTMENT.

President F. S. Kedzie,
East Lansing, Michigan.

Dear Sir:

A brief annual report of the Physics Department for the year ending June 30, 1921, is herewith presented.

The personnel of the department was as follows:

Charles W. Chapman, Professor of physics.
William E. Laycock, Associate professor of physics.
Edwin Morrison, Assistant professor of physics.
Eugene B. Butler, Instructor in physics.
Wilbur H. Thies, Instructor in physics.
S. Elizabeth Morrison, Laboratory assistant and clerk.
Ralph M. Harford, College photographer.
Wallace W. Tappan, Caretaker of the department.

Mr. Butler and Mr. Thies began their duties as instructors, September 1, 1920.

Practically no equipment has been purchased throughout the whole year, but through our own efforts some apparatus has been added. In one week we built 4 magnetometers the approximate cost of which would have exceeded $25 each had we bought apparatus of an equal grade. We have increased the capacity of our storage battery switchboard so that we now have 112 volts. Besides, we have again rewound our rotary converter. This policy was adopted by us in order that the Physics department might do its part in the conservation of funds at a time when the assistance of all departments was needed, as the college financial condition was practically in a state of bankruptcy.

The following revisions, and additions, have been made in and to our work in physics.

(a) Physics 4b, which has previously been a three-credit course, becomes a five-credit course.

(b) Laboratory fees have been revised as follows: fee for a two-hour laboratory period will be $1.50, while a $3.00 fee will be required for a four-hour laboratory period. Physics 5, laboratory fee will be $5.00.

(c) Physics 3d and Physics 3e which have been required of sophomore home economics students for several years past, now becomes an elective.

(d) Physics 3, "Mechanics and Electricity" (spring term-5 credits), will henceforth be required of freshman home economics students.

(e) The agricultural and engineering courses remain practically unchanged, with the following modification in laboratory work for the engineers (Physics 2f-spring term):

To make the engineering laboratory work of a higher collegiate grade and yet add to its practical value, six new laboratory problems were worked out to replace the six stereotyped experiments that have been used in practically all colleges for the last ten to fifteen years. One of the new problems combines three of the former

experiments, making a problem that commands the attention and respect of our engineering students. The remaining five experiments are also of equal importance.

(f) We have been authorized to give three years of physics as a minor in the Applied Science course, which will necessitate the engagement of an additional instructor during the year 1921–22, and possibly another in the year following.

The courses in physics taught and the number of students enrolled in each subject, were as follows:

	Students
Summer Term, 1920	
Preparatory physics	14
Physics 1e	8
Physics 2f	1
Physics 3d	1
Physics 3e	3
Physics 4b	13
Total	40
Fall Term, 1920.	
Physics 1d	143
Physics 2d	153
Physics 4a	12
Total	308
Winter Term, 1921.	
Physics 1e	129
Physics 2e	138
Physics 3e	107
Short course	39
Total	413
Spring Term, 1921.	
Physics 2f	118
Physics 3d	93
Physics 4b	15
Total	226
Prep. phys. lab. for partially disabled ex-service men	36
Total enrollment for the year	1,023

Physics 5 (for veterinary students) was eliminated, spring term, there being only one freshman veterinary student.

Physics 4c has not been offered for three years on account of the lack of laboratory room.

In the summer of 1907, the Physics department moved from the north half of the Chemistry Building into the Engineering Building where it had two lecture rooms, an apparatus room, a shop, three large laboratories used exclusively for physics—rooms that were about 40 feet by 50 feet—and three recitation rooms. Since the fire which destroyed the Engineering Building, March 5, 1916, we have been in very cramped and inadequate quarters. This means that much of the apparatus has had to be taken down,

put away and new apparatus set up for the different sections. Some of the apparatus is used in common by agricultural, home economics and engineering students in the basement hall of the Forestry Building, while the remainder of the apparatus is in their respective laboratories. This condition has necessitated smaller and scattered sections than would have been required had we had more and larger laboratories. Furthermore, the Engineering Laboratory will not accommodate more than 16 students at most and is better adapted for 12 or 14 students.

We now have only two rooms for lecture and quiz work; formerly we had five, well-planned rooms.

In view of the fact that we will be called upon to give three years' work in physics as a minor in the Applied Science course, whereas we have offered only one year's work to engineers; two terms' work to both home economics and agricultural students with a small group elective allowed, it becomes evident that if we are to do any work in physics of a high standard, more and suitable room must be provided in the very near future.

Due to the cooperation of both students and teachers, all work has been carried on as efficiently as such cramped quarters would permit.

Respectfully submitted,

CHAS. W. CHAPMAN,

Professor of Physics.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DEPARTMENT OF PHYSICAL TRAINING.

President F. S. Kedzie,

Dear Sir:

I respectfully submit to you the following report of the Department of Physical Training for the year ending June 30, 1921.

The year opened with several new additions in the teaching staff. George Clark came to us in the capacity of football and baseball coach, James Devers as instructor in gymnasium and the combative sports, Miss Jessie MacCornack as instructor in girls' work. The most important addition to the work was the establishment of the College Health Service with Dr. Clyde Reynolds as director. The work was established to give adequate health education, and medical and health care to all the students. A thorough medical and physical examination was given every entering student, a series of health talks were given all freshmen, while medical advice and medical attention were given all who were in need of such help. It is planned to extend this service just as far as possible and include both the sick and health program of the entire college. Miss Gertrude Loudenback, an instructor in girls' work was also added to the staff, coming to the College in April. L. L. Frimodig, J. G. Heppinstall, A. N. Smith and Miss Helen Grimes who were with us the previous year remained throughout the year and did excellent work. Physical training work was given throughout the year to all the students, both boys and girls. The work for girls consisted of formal gymnasium work, folk and æsthetic dancing, swimming, recreative games and athletics in all its phases. There was a marked improvement in the organization of the work for girls over previous years and the teaching was efficiently handled by the three instructors mentioned above. The girls have the use of the gymnasium

and swimming pool from 8:00 to 12:00 in the morning, leaving the entire afternoon and evening free for the men of the institution.

The gymnasium work for men was divided into twelve sections which, with the athletics and the girls' work brought the gymnasium into use from 8:00 a. m. to 8:00 p. m., six days in the week. Representative college teams were maintained in football, baseball, track, basketball and cross-country and all had fairly good seasons. Inter-class and inter-society teams were active in all the sports, and I believe there was more general participation in recreative activities than ever before.

There is need for more lockers in the gymnasium, as with our limited number it is necessary to put two or three in a locker, which is always unsatisfactory.

I wish again to respectfully call your attention to the necessity for a stadium or some adequate seating equipment for handling out-of-door sports. We cannot bring the strong western teams to our field under present conditions and it is bad for the institution to play all of our important games away from the College. Then, too, our present stands are becoming unsafe and we are told must be condemned very shortly.

Respectfully submitted,
C. L. BREWER,
Director of Physical Training.

East Lansing, Michigan June 30, 1921.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND PHYSIOLOGY.

To the President,

Sir: I have the honor to submit the following report of the Department of Zoology and Physiology for the year ending June 30, 1921:

There are few changes to be noted in the work of this department for the year. As forecast in my last report, Mr. Bergquist has been able to care for the work in geology in a most satisfactory manner and it has not been necessary to add a new instructor. The work in zoology and physiology has progressed normally and requires no special comment. Recent changes in curriculum are likely to require some additions during the coming year because of the reinstatement of physiology in the Home Economics course and the possible large increase of students in both physiology and zoology in connection with the Applied Science course. Naturally however, it is impossible to anticipate these at present.

A rather unusual amount of outside or extension work has been done during the year by several members of the department force. It has been customary for many years to call on this department for its stereopticon in connection with the various lectures and other entertainments given at the College, and at some seasons hardly a week passes that our instruments are not thus used. In addition, the head of the department and Professor Conger have given talks or addresses with some frequency before various clubs, societies and schools mostly in the immediate vicinity but occasionally at some distance.

The department has become much interested in the development of the fur farming industry in Michigan, particularly fox farming. Early last year the fox breeders of Muskegon county appealed to the College for assistance and advice in some of their problems and eventually we undertook investi-

gations along several lines in connection with the U. S. Biological Survey of the Department of Agriculture at Washington. Professor Conger has visited several of the Muskegon fox farms and has talked with the owners and others interested, and given some lectures on this new industry. It seems likely that this work will have to be carried on indefinitely and with increasing attention as the industry develops, but thus far it has not seemed expedient to issue any bulletin on this subject.

Two points of interest should be noted in connection with the general museum: One is the gift of about one hundred specimens of mounted birds by Mrs. J. W. Potter of Lansing, forming a welcome addition to our local collection. These birds were collected in the vicinity of Lansing, and were mounted by Mrs. Potter's father, Hiram Rossman, after he was eighty years old. The other item is the disappearance of one of the old attractions of the museum, the so-called war horse, Old Buckskin, which was ridden by Lieut. L. B. Baker of the U. S. Secret Service during the Civil war and was present at the capture of J. Wilkes Booth, Lincoln's assassin. This mounted specimen was presented to the College many years ago but through age and poor preservation originally, had deteriorated to such an extent that Lieut. Baker's relatives agreed that it would be better to have it removed from the museum. It was therefore destroyed and the saddle and bridle which had been merely loaned to the College were returned to the owners.

Respectfully submitted,

WALTER B. BARROWS,

Professor of Zoology and Physiology and

Curator of the General Museum.

East Lansing, Michigan June 30, 1921.

ANNUAL REPORT OF LIBERAL ARTS COUNCIL.

To the President and State Board of Agriculture:

Gentlemen: Members of the board of control for the current year:

Professor W. W. Johnston.
Professor C. P. Halligan.
Mr. J. B. Hasselman.
Professor W. H. French.

Student members:

Mr. W. A. Tobey.
Miss Dorothy Foster.

The liberal arts council has endeavored to provide wholesome, literary and musical entertainment from time to time during the college year, for the student body.

We have had a very excellent line of entertainments but have been handicapped in having a place to hold the meetings. We were finally granted the use of the gymnasium for a part of the meetings, through the kindness of President Kedzie and Physical Director Brewer.

Our experiences of the year lead us to make two recommendations to govern future activities:

First, that a regular place be provided for holding such entertainments so that every one will understand where they are to occur.

Second, that the president shall have a joint meeting of all the committees of the College, charged with the oversight of literary and social entertainments, in order that the schedule may be arranged so there will be no conflicting dates. Our greatest trouble during the past year has been that we were unable to find a date for some of the meetings that would not conflict with from one to four other entertainments that were being given on the campus.

The following is a list of entertainments held during the college year.

October	11—Hortense Neilson, reading	$125 00
November	1—Edward and Helen Atchinson, recital	100 00
November	29—Professor R. A. Tallcot, reading	75 00
January	10—Ellie Werner Kinney, literary reading	75 00
January	19—Elizabeth Lennox, musical recital	250 00
February	10—Hon. W. W. Ellsworth, address	100 00
February	24—Jessie V. Rittenhouse, address	100 00
March	1—Apollo male quartet	100 00
March	14—Jane Addams, address	75 00
April	7—M. A. C. glee club	200 00
April	19—Sam Higginbottom, address	50 00

In addition to the foregoing items of expense there have been bills for printing, labor and supplies. The entire financial statement for the year, showing receipts and expenditures, is appended hereto.

RECEIPTS AND DISBURSEMENTS—COMMITTEE ON LIBERAL ARTS.

School Year 1920-1921.

RECEIPTS.

June 30, 1920.	Balance on hand	$537 54	
	Student fees	1,555 14	
	Gate receipts	134 25	

DISBURSEMENTS.

June 30, 1921.	Refund to students		$0 68
	Labor		167 50
	Entertainments		1,245 00
	Printing		26 95
	Miscellaneous		111 30
	Balance on hand		675 50
		$2,226 93	$2,226 93

Respectfully submitted,

W. H. FRENCH,

Chairman Liberal Arts Council.

East Lansing, Michigan. June 30, 1921.

THIRTY-THIRD ANNUAL REPORT

OF THE

EXPERIMENT STATION

OF THE

Michigan Agricultural College

UNDER THE HATCH AND ADAMS ACTS

FOR THE

YEAR ENDING JUNE 30, 1920

For members and organization of the State Board of Agriculture in charge of the Station and list of officers, see pages 5 and 13 of this volume.

REPORT OF SECRETARY AND TREASURER

THE FOLLOWING SHOWS THE RECEIPTS AND DISBURSEMENTS OF THE EXPERIMENT STATION FOR THE YEAR ENDING JUNE 30, 1921.

		Dr.	Cr.
July 1, 1920.	To balance	....	$00 00
Aug. 18, 1920.	received from U. S. treasury	$7,500 00	
Oct. 22, 1920.	received from U. S. treasury	7,500 00	
Jan. 13, 1921.	received from U. S. treasury	7,500 00	
April 18, 1921.	received from U. S. treasury	7,500 00	
June 30, 1921.	State treasurer, one-fifth mill fund	197,013 29	
	license fees, commercial fertilizer	8,940 00	
	license fees, commercial feeding stuffs	16,480 00	
	Graham horticultural experiment station	458 70	
	Upper Peninsula experiment station	6,492 91	
	South Haven experiment station	685 62	
	farm and miscellaneous receipts	5,968 87	
	By disbursements as per vouchers filed in office of the State auditor general	....	266,039 39
	Total	$266,039 39	$266,039 39

Twenty-five thousand regular bulletins No. 288; forty-five thousand regular bulletins No. 289; forty-five thousand regular bulletins No. 290; twenty-five thousand regular bulletins No. 291; twenty-two thousand regular bulletins No. 292; twenty-three thousand special bulletins No. 102; ten thousand special bulletins No. 103; eight thousand special bulletins No. 104; thirty thousand special bulletins No. 105; thirty thousand special bulletins No. 106; forty seven thousand circular bulletins No. 44; five thousand circular bulletins No. 45; five thousand circular bulletins No. 46; ten thousand circular bulletins No. 47; four thousand technical bulletins No. 49; four thousand technical bulletins No. 50; four thousand technical bulletins No. 51; fifty thousand quarterly bulletins Vol. 3, No. 1; fifty thousand quarterly bulletins Vol. 3, No. 2; fifty thousand quarterly bulletins Vol. 3, No. 3; forty-five thousand quarterly bulletins Vol. 3, No. 4, have been issued by the Experiment Station during the fiscal year.

DISBURSEMENTS ON ACCOUNT OF U. S. APPROPRIATIONS.

	Hatch fund.	Adams fund.
Salaries:		
Director and other administrative officers	$1,900 00	
Scientific staff	3,550 00	$800 00
Assistant to scientific staff	9,550 00	14,200 00
Totals	$15,000 00	$15,000 00

DISBURSEMENT OF EXPERIMENT STATION MONEYS—OTHER THAN RECEIVED FROM U. S. TREASURER.

Salaries	$99,227 46
Labor	44,579 39
Publications	21,396 17
Postage and stationery	1,732 58
Freight and express	915 90
Heat, light, water and power	1,018 04
Chemicals and laboratory supplies	7,642 32
Seeds, plants and sundry supplies	8,369 76
Fertilizers	3,409 73
Feeding stuffs	5,865 53
Library	641 54
Tools, machinery and appliances	4,242 94
Furniture and fixtures	935 29
Scientific apparatus and specimens	1,561 22
Live stock	3,369 04
Traveling expenses	12,166 55
Contingent expenses	6 50
Buildings and land	18,959 48
Total	$236,039 39

REPORT OF THE DIRECTOR OF THE EXPERIMENT STATION.

To President F. S. Kedzie:

The activities of the Experiment Station during this year continued to return to normal after the interruptions of the war period. The appropriation of more funds and the employment of additional workers during the year afforded much relief. Very satisfactory progress was made in equipping and developing the work of the Upper Peninsula Station at Chatham and also the Graham Fruit Station at Grand Rapids. Particulars relating to these important activities are included in department reports or special publications.

During this year the director's office was given valuable assistance by Mr. E. B. Hill, who aided with the general detail work of the office and assumed the entire responsibility for publications. Publication costs have increased to such an extent as to impose restrictions relative to numbers and sizes of bulletins as well as size of editions.

The news letter for county agents and extension workers established during this year by the office of the director of extension has become an important medium of conveyance of timely items of information for immediate use by those in the extension service.

For a period extending back to the time of organization of the Experiment Station, this institution has participated in regulatory work including inspection of fertilizers and later feedstuffs, fungicides and insecticides as well as the direct or indirect supervision of orchard, nursery, and apiary inspection. With the termination of the present fiscal year all these activities have been transferred to the Department of Agriculture, established by an enactment of the last Legislature.

Especial mention should be made of the achievements and results of the Crop section by way of development of new varieties which have been placed in the farmers' hands in a satisfactory way through cooperation with the experiment association.

The following statement includes the funds disbursed during the year indicating their source:

Hatch	$15,000 00
Adams	15,000 00
State	156,063 29
Total	$186,063 29
Upper Peninsula	$12,250 00
Graham Station	24,000 00
South Haven Station	2,700 00

The three sub-station funds are included in the State fund given above.

LIST OF BULLETINS.

No. Regular:
228—Commercial feeding stuffs.
289—Corn growing in Michigan.
290—Soil fertility.
Special:
103—Forest planting in Michigan.
104—Soils of the Detroit area.
105—Rosen rye.
106—Sugar beet growing in Michigan.
Circular:
44—European corn borer.
45—Hughes annual white sweet clover (Hubam).
46—Sweet clover.
47—Poisoning from bacillus botulinus. Cause; prevention; treatment.
Technical:
49—Studies in infectious abortion.
50—Rate and extent of solubility of minerals and rocks under different treatments and conditions.
51—Studies on the reactions between soils and various chemical compounds.

Respectfully submitted,
R. S. SHAW.
Director of the Experiment Station.

East Lansing, Mich., June 30, 1921.

REPORT OF THE ANIMAL HUSBANDRY SECTION.

Director R. S. Shaw,

Dear Sir:

I have the honor to submit the following report of the experimental work conducted by the Animal Husbandry section during the past year.

Another year's work on the use of stover silage for fattening steers has been concluded. The work this year embraced three lots of steers. Lot 1, was fed normal corn silage as previously, lot 2, stover silage, and lot 3, stover silage plus an amount of corn equal to that which was removed from the stover when it was placed in the silo. Lot 1 made an average daily gain of 1.94 pounds; lot 2, 1.42 pounds and lot 3, 1.58 pounds. Not only was the gain greater in lot 1 but the cost was much lower in lot 1 than in the other two lots, both of which averaged about the same in cost. The results this year were decidedly in favor of placing the corn in the silo along with the stover or the making of normal silage. Plans are already under way for the repetition of this work the coming winter. It is earnestly hoped that before another year facilities will be added to our equipment to permit the handling of a much larger number of steers, as the feeding of one carload in our present quarters greatly overcrowds the beef breeding herd, and a single carload of steers does not provide a sufficient number of animals to work out the various angles entering into the question of the use of stover silage.

The experimental work with pig feeding as reported last year is being repeated, as we felt that the amount of grain required to produce 100 pounds of pork as shown in the tests reported was rather large, and an effort is being made to discover if there is any reason for this. The tests will be repeated twice, making five trials in all before the work is reported on, which we think will be sometime early next spring.

Respectfully submitted,

GEO. A. BROWN,

Professor of Animal Husbandry.

East Lansing, Mich., June 30, 1921.

REPORT OF THE ANIMAL PATHOLOGY SECTION.

Directors R. S. Shaw,

Dear Sir:

I herewith submit the report of the Animal Pathologist for the year ending June 30, 1921.

Two problems have been studied the last year, namely, the pathology of pyometra in cattle, and the effects of medicinal agents on the uterine mucosa of the cow.

A report of this work has been submitted for publication as Technical Bulletin No. 54, and a detailed discussion here would be unnecessary repetition. Briefly, it may be said that pyometra is a common and serious sequel of abortion infection and is characterized by a purulent inflammation of the

uterus with the accumulation of more or less pus in the uterine cavity. But little work has been done upon the pathology of this condition in cattle and appreciating the importance of a knowledge of the pathology of any affection as a guide in outlining a rational treatment, it was considered advisable to devote some time to a study of this condition.

This preliminary study indicates that the essential lesions in the uterus in this condition are, a superficial and more or less general necrosis of both the gland mucosa and the region of the cotyledons of the uterine mucosa; and leucocytic infiltration and fibrosis of the superficial portions of the stroma. The depth of the necrosis varies from fifty microns to eight-tenths of a millimeter and in places produces many minute ulcers extending more deeply into the uterine mucosa. In one case of a more chronic nature the most conspicuous alteration was the presence of numerous small cysts in the uterine mucosa. Cystic ovaries are of frequent occurence in sterile cows but to the writer's knowledge this condition of the uterine mucosa has not been reported.

The condition observed in this case may explain the occurrence of nymphomania in cows in which cystic ovaries are not clinically recognizable.

The other problem studied was undertaken with the hope of throwing some light on the changes produced in the uterus by the usual treatment of the catarrhal conditions. The use of irritants in the treatment of these conditions is a long established practice and many gynecologists have condemned the use of them, assuming that their use possibly produces changes that interfere with subsequent pregnancies. In this work concentrated preparations of iodine were injected into the uterine cavity and also used to swab the cervical mucosa. The treated animals were slaughtered at varying intervals of time and a gross and histological examination made of the reproductive organs.

The observations made in these cases indicate that the use of such preparations produces an acute fibrinous imflammation of the uterine mucosa with superficial necrosis; the necrotic zone varying in depth from twenty microns to one millimeter. Sloughing of the necrotic zone and regeneration of the epithelium are initiated within forty-eight to seventy-two hours after treatment. Out of ten cases treated there were three in which the treatment apparently caused the rupture of a bloodvessel resulting in a hematoma. In one of these the cow was in heat, another was menstruating, and another was in the early stage of pregnancy (pregnancy not diagnosed before treatment). In each of these conditions there is an engorgment of the bloodvessels and the thought is suggested that such treatment about the time of estrum or menstruation may be a dangerous practice.

The results indicate that repair is more or less complete in about two weeks and but little, if any, fibrosis results from the treatment administered in these cases.

Respectfully submitted,
E. T. HALLMAN,
Animal Pathologist.

East Lansing, Mich., June 30, 1921.

REPORT OF THE BACTERIOLOGICAL SECTION.

Director R. S. Shaw,

Dear Sir:

Progress can be reported on every problem outline in our report of the preceding year. No changes have been made in the projects as outlined in that report. Research Assistant, Robert L. Tweed, in charge of Adams 1a, reports on his work as follows:

During the past year one-third of my time (winter term) has been spent teaching and two-thirds with technical research and work of a popular nature.

Under project, Adams 1a, "The effect of diseases in the cow upon the milk", I have under way experiments relating to the following phases of the problem as applied to infectious abortion.

1. Studies upon the significance of high cellular counts from *Bact. abortus* infected udders as compared with non-infected udders.
2. A study of the teats as an avenue of *Bact. abortus* infection of the udder.
3. Feeding experiments with *Bact. abortus* infected milk.
4. Study of strains of *Bact. abortus* and abortus-like organisms isolated from milk.
5. Efforts to devise better methods for studying the presence of *Bact. abortus* in the udder.

Under my direction, also, graduate assistant, O. H. Friedeman, has under way "A study of the nature of *Bact. abortus* infection of the udder" the results of which he expects to submit as a master's thesis.

My work of a popular nature has consisted of bacteriological examination of 26 fecal specimens, from as many different cases suffering from intestinal disorders. In the majority of these cases a diet was recommended supplemented with some form of fermented milk. The laboratory has furnished 162 quarts of this milk with 75 per cent of the cases reporting beneficial results from the fermented milk as part of the diet.

I have also made 15 autogenous vaccines for the treatment of chronic bacterial infections, 6 complete blood counts, 2 blood cultures, 2 examinations of human milk being used for infant feeding, and 5 examinations of milk for the presence of *Bact. tuberculosis*.

[Robert L. Tweed.]

In the report of progress made by Research Associate Ruehle on Adams project 1b, I would call your attention in particular to the recommendations relative to cooperation with the Sections of Chemistry and Dairy Husbandry. From the standpoint of economy, efficiency and determination of speedy results this co-operation is imperative. Mr. Ruehle's report follows:

My time was devoted this year to three lines of effort, namely, (1) teaching; (2) work of a popular nature, and (3) research work on the "Keeping quality of butter," (project, Adams 1b).

The work of a popular nature consisted in answering numerous letters of inquiry relative to dairy hygiene, and inspection and analyses of the milk supplies of East Lansing and the College. Several minor investigations were made of the sanitary condition of various dairy products but nothing was found of sufficient interest to warrant a description of the work.

The research work on the "Keeping qualities of butter," was continued along the line of the work done last year. At the October meeting of the Lansing section of the Society of American Bacteriologists, a paper was read on the subject, "Metallic flavor in dairy products with special reference to butter". The following is an abstract of this paper, which appeared in the March, 1921, issue of "Abstracts of Bacteriology":

Experiments were conducted in which iron lactate and copper lactate at the rate of 200 parts per million were added to cream that was made into experimental butters. The latter were studied both when fresh and after a period of cold storage. It was found that both salts were capable of producing the flavor in fresh butter. In storage butter the metallic flavor was followed by tallowiness and fishy flavor in the case of the addition of copper lactate, and of indefinite off flavors in the case of iron lactate.

Two bacteria of the *B. subtilis* group, one isolated from metallic flavored butter and the other from a sample of bitter milk, when inoculated into the cream which was then made into butter, produced the flavor very faintly when the butter was fresh, but after varying periods of storage produced the flavor to a notable degree.

Other members of the *B. subtilis* group when inoculated into fresh milk, produced the flavor in 24 to 72 hours when the milk was held in an ice box. The rapidity of development of the flavor seemed to be correlated with the ability of the microorganisms to produce peptonization of litmus milk when held at 37° C. The members of the *B. subtilis* group which were found to produce metallic flavor were (1) *B. mycoides;* (2) *B. megatherium;* (3) *B. vulgatus,* (*mesentericus vulgatus*); (4) *B. ramosus;* (5) *B. subtilis* (laboratory strain) and (6) *B. subtilis* (American museum of natural history strain). A control tube was not metallic but the addition of Difco 'peptone' resulted in a flavor very similar to metallic.

Further experiments are in progress and will be reported fully later.

Since the above abstract was written it has been discovered that one of the bacteria referred to in the paragraph beginning 'Two bacteria of *B. subtilis* group', etc., is not a member of the *B. subtilis* group, but is probably *B. fluorescens liquefaciens.* This is the organism which was isolated from bitter milk, reported two years ago. (See Ann. Report Bact., 1919). A more rigid examination of the above mentioned organisms may result in a revision of names.

A summary of the same data appeared also on page 103 in the February, 1921 issue of the Experiment Station Quarterly under the title of "Off-flavors in Butter". A fuller account of these investigations is being prepared for presentation to a suitable journal.

It is planned to continue this work and other similar work as soon as sufficient funds are available to support it. In the meantime a study is being made of the microflora of off-flavored butters, with the view to comparing their floras with those of good flavored butters. In this way it is hoped to lay the foundation for future work in this field.

I suggest that it would be well to ask the Chemistry section to cooperate with us on this problem, even to the extent of becoming jointly responsible for the project (Adams 1b). I find it impracticable to do the necessary chemical work myself. At the present time it is desirable to determine whether certain off-flavored butters have appreciable amounts of iron, copper, lead or zinc salts present and, if so, to what extent. Some of the work which I have done, and work done at other places, suggests that these salts are the exciting cause of certain off-flavors, notably metallic and tallowy flavors. A large

number of samples of butter should be examined for their content of these metals and experiments should be performed to show the amounts required to produce the results, the chemical reactions taking place and the conditions which determine what takes place.

It would be advantageous also to have the Dairy section partly responsible for the project, since they are in closer touch with the buttermaking industry and could give the work a practical direction and interpretation, as well as assist us in the manufacture of experimental butters and in the judging of the butters being studied.

[G. L. A. Ruehle.]

I take the liberty to quote from my report for this year to the president:

"It is with no small measure of regret that I announce the retirement by resignation of Mrs. Zae Northrup Wyant at the close of the fiscal year. I shall take occasion to speak of her work in my report to the Director of the Experiment Station. When I took charge of the laboratory in 1912, she was engaged in research exclusively. Since then she has been under the necessity of teaching many classes under many circumstances. Without fail, she has measured up to the responsibilities and with ability, energy and rare good nature she has proved what had already been demonstrated in the field of investigation, that in the students' laboratory she could command the respect of and stimulate and inspire all. Her capacity for work and versatility in a setting of rare good humor is without equal in my experience. She leaves a lasting impress on this institution and on the science of bacteriology."

A very casual study of this Experiment Station's records for the past fourteen years will reveal the tremendous amount of worth while work accomplished by Mrs. Wyant. There are to her credit a considerable number of technical bulletins, popular bulletins, and lengthy contributions to the annual reports in the field of dairy, soil, fermentation, entomological and general bacteriology. She has also to her credit numerous scientific and popular papers in the current periodicals and journals. Her resignation meant a distinct loss to the College and Station and we fear to science, and put us in the very difficult position of locating a worthy successor, competent to carry on her work.

Research Associate Zae Northrup Wyant, in leaving, places in our hands a complete record of her unpublished work.

The following is a brief report of some of the work which, for the past year and practically up to the present time, has been under her immediate supervision:

Silage poisoning: Fourteen samples of silage, two samples of oats, and one each of corn and hay were sent in for analysis. Either they were suspected of poisoning stock or merely sent in to see whether they were fit to feed. *B. botulinus* was found in none of the samples, although cultures from several of the samples were suspected of containing these organisms. Two samples of silage were good and their feeding was recommended.

No silage inoculation experiments were carried on this year.

Flax retting: No work has been done until the last few weeks of the year upon this problem. Miss Trevithick, a student, is just beginning some research work upon this subject under the direction of Mr. Tweed.

Vinegar: From July 1, 1920 to June 30, 1921, two hundred ninety three requests for vinegar cultures were received; 329 yeast cultures were sent out, not including 25 gallons of starter sent to a Michigan canning company for manufacturing vinegar stock, also 332 cultures of acetic bacteria and 56 lots

of chemicals for making honey or maple syrup vinegar. Of the batches of chemicals, 53 were for making honey vinegar, and 2 for maple and 1 for molasses vinegar. Most of the honey vinegar cultures were sent out of the state. In addition potassium metabisulfite was sent to two different people to aid in controlling of fermentations.

The increase in requests for vinegar cultures appears to be due largely to timely articles on vinegar which have been published in the quarterly bulletin, or to reviews of Special Bulletin No. 98 on "Vinegar" published in various farm papers. A considerable number of the requests for honey vinegar have resulted from the publicity gained by an article entitled "Profit in Honey Vinegar," written by R. H. Kelty of the Entomological section and published in the November, 1920 number of "Gleanings in Bee Culture".

Requests for vinegar cultures were received from 53 counties this year as against 26 counties last year; thirty four of the 53 counties ordered no cultures last year, while only 7 of those obtaining cultures last year, failed to send in a request this year. This makes an increase of 27 counties or one more than double the number of counties reached by the quarterly bulletin and other advertising methods this year. Of the 293 requests, 196 came from Michigan counties, and 97 were from other states and from Canada.

The table follows:

NUMBER OF REQUESTS FOR VINEGAR CULTURES SENT OUT FROM JULY 1, 1920 TO JUNE 30, 1921.

Counties.	1920 1921.	Counties.	1920 1921.	Counties.	1920 1921.
Alcona	2	*Gratiot	4	*Montcalm	3
Allegan	4	*Hillsdale	2	*Muskegon	2
*Antrim	5	*Huron	6	*Newaygo	5
*Arenac	6	Ingham	18	Oakland	7
*Barry	4	*Ionia	1	Oceana	4
*Bay	4	*Iosco	1	*Ogemaw	1
*Benzie	9	*Isabella	6	Osceola	2
Berrien	3	Jackson	4	*Otsego	1
*Calhoun	6	Kalamazoo	4	*Ottawa	4
Cass	3	*Kent	5	*Saginaw	4
Charlevoix	6	*Lapeer	2	*Sanilac	3
*Chippewa	1	Livingston	2	Shiawassee	2
*Clare	1	*Luce	1	*St. Joseph	3
*Delta	1	Macomb	2	*Tuscola	2
Eaton	4	Manistee	1	Washtenaw	14
*Emmet	2	*Mecosta	1	Wayne	1
Genesee	9	*Midland	1	Wexford	0
*Gladwin	2	Monroe	2		
				Total—53 counties	196

*New counties this year.

NUMBER OF REQUESTS FOR VINEGAR CULTURES FROM OUT OF STATE JULY 1, 1920 TO JUNE 30, 1921.

States.	1920 1921.	States.	1920 1921.
Arkansas	2	New Jersey	1
California	2	New Mexico	1
Connecticut	1	New York	5
Florida	1	North Carolina	1
Idaho	2	North Dakota	1
Illinois	6	Ohio	14
Indiana	3	Oklahoma	2
Iowa	5	Pennsylvania	13
Kansas	1	South Carolina	1
Maine	2	Texas	1
Massachusetts	7	Utah	1
Minnesota	6	Washington	3
Montana	1	Wisconsin	3
Nebraska	3	Canada	7
New Hampshire	1		
		Total	97

NUMBER OF VINEGAR CULTURES SENT OUT FROM JULY 1, 1920 TO JUNE 30, 1921—COMPARED WITH THOSE SENT OUT THE PREVIOUS YEAR.

Altogether 659 vinegar cultures were sent out this past year, 456 to Michigan and the remaining 203 to other states and Canada. The following table gives the data for Michigan counties and for other states.

Michigan Counties.	1919 1920.	1920 1921.	Counties.	1919 1920.	1920 1921.	Counties.	1919 1920.	1920 1921.
Alcona.........	4	4	*Gratiot.........	0	6	*Montcalm.....	0	3
Allegan........	3	5	*Hillsdale.......	0	2	*Muskegon.....	0	4
*Antrim.........	0	6	*Huron.........	0	14	*Newaygo......	0	9
*Arenac.........	0	21	Ingham........	5	27	Oakland.......	1	15
*Barry..........	0	4	*Ionia..........	0	1	Oceana........	5	6
*Bay...........	0	6	*Iosco..........	0	2	*Ogemaw.......	0	1
*Benzie.........	0	58	*Isabella........	0	9	Osceola........	3	2
Berrien.........	4	6	Jackson........	7	10	*Otsego.........	0	1
*Calhoun........	0	8	Kalamazoo.....	1	3	*Ottawa........	0	9
Cass...........	1	4	Kalkaska.......	2	1	*Saginaw.......	0	8
Charlevoix......	2	9	*Kent...........	0	7	*Sanilac........	0	5
*Chippewa......	0	1	*Lapeer.........	0	2	Shiawassee.....	1	11
*Clare..........	0	1	Livingston......	1	3	*St. Joseph......	0	9
*Delta..........	0	2	*Luce...........	0	2	*Tuscola.......	0	13
Eaton..........	2	9	Macomb.......	1	2	Washtenaw....	3	3
*Emmet.........	0	10	Manistee.......	2	2	Wayne........	2	12
Genesee........	2	62	*Mecosta........	0	1	Wexford.......	0	1
*Gladwin........	0	4	*Midland........	0	28			
			Monroe........	0	2	Total cultures	......	456

*New counties this year.

NUMBER OF VINEGAR CULTURES SENT OUT FROM JULY 1, 1920 TO JUNE 30, 1921—COMPARED WITH THOSE SENT OUT THE PREVIOUS YEAR.

States.	1919 1920.	1920 1921.	States.	1919 1920.	1920 1921.
Arkansas........................	0	2	New Hampshire...............	2	2
California......................	0	2	New Jersey....................	0	1
Connecticut....................	0	1	New Mexico....................	0	1
Florida.........................	0	4	New York......................	1	14
Idaho...........................	0	3	North Carolina................	0	1
Illinois.........................	2	8	North Dakota.................	1	1
Indiana.........................	2	6	Ohio..........................	2	39
Iowa............................	4	4	Oklahoma.....................	0	3
Kansas..........................	0	5	Pennsylvania..................	1	45
Maine...........................	4	14	South Carolina................	0	2
Massachusetts..................	2	9	Texas.........................	0	2
Minnesota......................	0	11	Utah..........................	0	2
Mississippi.....................	4	0	Washington...................	2	4
Montana........................	0	1	Wisconsin.....................	2	4
Nebraska.......................	0	4	Canada........................	0	8
Total cultures..................	......	......	....	......	203

FIFTY-NINE SAMPLES OF VINEGAR WERE TESTED AS FOLLOWS

Sample No.	Per cent. Acetic acid.	Per cent. Alcohol by wt.	Sugar.	Color.	Flavor.	Remarks.	Suggestions.
146	1.1	0.91	+	Pale yellow			N. G.
147	2.1	2.88	++	Pale yellow		Turbid	Pasteurize, put in a clean bbl. and inoc. with Bact. aceti.
148	0.9	3.15	+	Amber		Odor of linament	
149	2.6	3.75	++	Light amber		Cloudy	Ventilate and keep warm. But few foreign organisms present.
150	1.7	4.4	+	Medium amber.	Face cream	Full of gas bubbles	Ventilate and inoc. with Bact. aceti.
151	2.6					Vinegar eels	Eliminate eels and reinoc. with Bact. aceti.
152	6.3	0.38	+++	Dark amber	Fine	Clear	O. K.
153	6.2	1.08	+++	Deep amber	Fine	Dead vinegar eels	May dilute to 4% and strain to get rid of dead eels.
154	0.6	4.39	+	Pale amber	Good cider	Very cloudy	Clarify with gelatin and inoc. with Bact. aceti, aerate.
155	1.2	2.88	+	Light amber		Cloudy	Ventilate.
156	1.1	0.41	Sl. tr.	Light amber		Cloudy	N. G.
157	1.1	4.35	Sl. tr.	Light amber		Cloudy	Ventilate.
158	6.6		++	Dark amber	Fine cider	O. K.	O. K. for sale. May be diluted to 4%.
159	1.0	3.22	++	Light amber	Good	No eels	Ventilate and inoc.
160	1.2	3.35	++	Very light amber	Flat	No eels	Ventilate and inoc.
161	0.8	5.40	+−	Dark amber	Strong alcohol		Ventilate and inoc.
162	1.3	2.76	++	Light amber		Cloudy	Ventilate and inoc.
163	5.7			Med. light amber	O. K.		O. K.
164	2.0	4.52	Tr.	Med. light amber	O. K.	Vinegar eels	Pasteurize, ventilate and inoc.
165	0.8	9.59	0	Light yellow	O. K.	Dead eels	Pasteurize, ventilate and inoc.
166	0.8	6.79	0	Light yellow	O. K.	No eels	Pasteurize, ventilate and inoc.
167	0.9	5.35	0	Dark amber	O. K.	No. eels	Pasteurize, ventilate and inoc.
168	1.8	3.71	Sl. tr.	Light amber	Good, not acid		Ventilate and inoc.

169	5.8	....	....	Medium amber..	....	....	O. K. for sale.
170	5.5	....	....	....	....	....	O. K. for sale.
171	2.5	....	....	Light amber....	....	Vinegar eels........	Sample too small for alc. test.
172	1.2	4.15	+−	Light amber....	....	Vinegar eels........	Filter, ventilate and inoculate.
173	0.5	4.66	Tr......	Light amber....	....	Fair........	Inoc. with Bact. aceti.
174	0.5	3.22	Tr......	Light amber....	Fair........	Barely 4% acid possible........	Add 5½ lb. sugar to test 2 bbls. and allow to continue fermenting.
175	0.8	3.96	+	Light amber....	Fair........	Barely 4% acid possible........	
176	1.3	3.01	Tr......	Light yellow....	....	Vinegar eels........	Pasteurize, filter, inoc. and ventilate.
177	0.8	1.14	++++	Light amber....	Fine........	Fermentation still going on........	Put in warm place to finish alc. fermt. then inoc. with Bact. aceti.
178	2.3	+	....	Very light yel..	....	Made with lab. cult........	....
179	2.8	3.12	++	Med. amber....	....	Darkened as if iron or tannin........	Ventilate.
180	0.8	3.52	+++	Light yellow....	....	Sl. cloudy........	Ventilate and inoc.
181	4.3	....	+	Med. amber....	....	Eels, +++........	Rid of eels and store in clean sulfured casks.
182	4.3	....	+−	Light amber....	....	Eels, +........	Rid of eels and store in clean sulfured casks.
183	0.0	6.39	+++	Med. yellow....	Alcoholic, bitter....	....	Inoc. with Bact. aceti.
184	1.3	5.09	+++	Light amber....	Bitter........	Honey vinegar........	Past., strain into clean bbls. and inoc.
185	0.0	0.00	....	....	....	Wild ysts........	N. G.
186	2.6	5.98	+	Straw........	Clear acid........	....	Keep warm, ventilate.
187	1.6	1.13	+	Amber........	Clear acid........	....	Keep warm, ventilate.
188	1.5	8.88	+	Amber........	Clear acid........	....	Keep warm, ventilate.
189	1.1	1.15	+	Straw........	Clear acid........	....	N. G.
190	1.4	0.81	+−	Amber........	Clear acid........	....	N. G.
191	1.0	5.78	....	Amber........	Clear acid........	....	Keep warm, ventilate.
192	1.2	7.38	+	Amber........	Clear acid........	....	Keep warm, ventilate.
193	1.3	5.34	+	Amber........	Clear acid........	....	Keep warm, ventilate.
194	1.8	6.46	+−	Amber........	Clear acid........	....	Keep warm, ventilate.

FIFTY-NINE SAMPLES OF VINEGAR.—Concluded.

Sample No.	Per cent. Acetic acid.	Per cent. Alcohol by wt.	Sugar.	Color.	Flavor.	Remarks.	Suggestions.
195	1.6	6.05	++	Amber	Clear acid		Keep warm, ventilate.
196	4.9			Light amber	Clear acid	Too small sample for alcohol test	Mix 196 and 197 for sale.
197	3.9			Amber	Clear acid	Too small sample for alcohol test	Mix 196 and 197 for sale.
198	2.2			Light amber	Clear acid	Too small sample for alcohol test	Send larger sample.
199	1.1	7.82	+	Unclean acid			Ventilate, keep warm and inoc with Bact. aceti.
200	0.6	4.86	+	Light amber	Bitter		Ventilate and inoc.
201	0.6	4.63	++	Amber	Alcohol		Ventilate and inoc.
202	0.5	5.80	+	Light amber	Bitter		Ventilate and inoc.
203	5.8			Dark		Ferric and ferrous salts present	Aerate and clarify.
204	0.2	1.62		Bitter		Cloudy	Inoc. with yeasts.

Ten out of the 59 samples analyzed were found to be market standard (4 per cent) or above, while only 5 were found to be worthless. The remaining 44 samples theoretically would make good vinegar if optimum conditions are provided for the vinegar organisms.

Several parties have, in this and other states, made inquiry concerning making cider and other vinegars on a large scale. The technical portions of these inquiries were referred to the Farm Mechanics department.

The new prohibition law has caused the farmers and others who have vinegar to sell or wish to make vinegar to sell, or wish to keep their cider sweet, to send inquiries to this laboratory concerning the legal formalities necessary for obtaining permission. All such inquiries were referred to the federal prohibition director, Federal Building, Detroit. Many inquiries have also come in with regard to methods of preserving sweet cider. Pasteurization was recommended and in a few cases where the labor and expense of this would be too great, the addition of 0.1 of 1 per cent of sodium benzoate was advised.

An instructor in the Clemson Agricultural College, South Carolina, was interested in making vinegar out of waste watermelons. Advice as to the method of procedure was given, but the first attempts were unsuccessful. The experiment will be repeated this year, using further precautions suggested since it seems that there is no reason why vinegar could not be made from this raw material.

Twenty-five gallons of yeast starter was sent in the fall upon request to a Michigan canning factory, which utilizes its by-products as vinegar stock.

A few samples of vinegar have been received which showed the typical darkening due to soluble iron salts or to tannin. Analysis proved iron to be present. For the remedy the owner was referred to Special Bulletin No. 98.

A New York commercial firm dealing in beverages requested that this laboratory furnish them with commercial quantities of the vinegar yeast and bacteria. This request was refused but the name of a commercial biological supply laboratory near the beverage supply company was suggested as a possible source of continual supply. Evidently a satisfactory agreement was made since a request for the two vinegar cultures was received by this laboratory from the biological supply laboratory.

FOOD.

Pickles: One request was received for information as to why cucumber pickles became mushy. It was advised to use paraffin to exclude the air during and after the fermentation since the organisms causing this type of decomposition in pickles need air for growth.

Pectin: A large Chicago mail order firm requested information as to the advisibility of using pectin in making jellies, and also wanted to know what kind and size of package would appeal most to the housewife. Since the laboratory has carried on some experiments with commercial pectin, it was advised that this product has a certain place in the household for use with fruit juices containing little or no pectin. The information was given that the commercial pectin used was put up in quart seal fast jars and was preserved with benzoate of soda.

Canned peas: A sample of canned peas removed from the can and placed in a sterile bottle was sent in for analysis since they didn't "taste right". Since it is very difficult for one trained to handling material "aseptically" to remove food from a can and place it in a sterile container, it is very probable that these peas were contaminated in this way and of course the germs

had a favorable opportunity to grow while the sample was in transit. Needless to say many bacteria of different types were found to be present but *B. botulinus* was not found. This is probably the information which was desired anyway, since the several outbreaks of botulism have stimulated the housewife to be on the alert for spoiled canned goods.

Canned corn: Three samples of canned corn were sent in for analysis. One sample was said to taste sour and the question was asked: "Is *B. botulinus* present?" Yeasts, diplococci and a few small gram positive rods in short chains, but no *B. botulinus* was found. The can containing the second sample of corn had a cracked cover. It was stated that many of the cans of corn of this pack showed the same phenomenon. It was not easy to say whether the covers were defective or whether so much gas formed in the can that the cover could not stand the strain. In every case, it was stated, the corn was apparently contaminated with microorganisms. The corn in this particular case was moldy, slimy, contained quantities of gas and many small flies and their larvæ. The corn had a sour, putrid odor. No spore-forming organisms were found to be present, consequently the cracked cover was attributed to defective glass or too strong a spring.

A sample of commercially canned corn was placed at 65° C. to see whether it contained thermophiles before inoculating with a pure culture of a thermophile already isolated. This corn, after about two weeks' incubation, was found to have an odor and to contain a thermophile resembling the pure culture. The corn was very much disintegrated and mushy, and considerable gas was present.

Canned string beans: The beans, canned in glass, had been opened and touched with the fingers to determine their consistency which was said to be mushy. They were said to have an off odor. Microscopical examination proved them to contain but very few organisms. There was no gas, no sediment and the juice was clear. These beans were evidently all right since cultural tests were negative.

Canned tomatoes: The tomatoes examined were canned by the open kettle method. This can (sealfast) was a leak. The tomatoes appeared full of gas and somewhat disintegrated, but the odor was normal. A slender rod with a terminal spore was isolated and found to be the cause of the gas production.

Canned beets: A can of commercially canned beets was brought in which appeared to be all right but on opening, the beets were found to be black, and this blackening was found to extend to the center of the beet. The odor and taste was said to be normal. Gram negative gas forming bacteria resembling *B. tetani* morphologically, were found to be numerous as also were large gram positive sarcines.

Canned pineapples: A swelled can of commercially packed pineapples, supposed to be poisonous, was examined and found to contain only yeasts in numbers. The odor and taste was of ethyl alcohol. Analysis showed 4.16 per cent alcohol by weight to be present. Guinea pig inoculation proved negative.

Canned pickled pears: These pears had been removed from a commercially canned gallon can which was a swell. The contents were thought to be poisonous. The juice had a bluish fluorsecence. Two pure cultures (gram negative) isolated were very vigorous gas producers at 37°. They were not *B. botulinis* however.

Canned asparagus: This can was not a swell but the liquid was cloudy.

Gram positive rods were found to be present but cultural and animal inoculation tests were negative.

One of the state hospitals which does its own canning had trouble with spoilage of their fruits and vegetables. The cans used were 2 qt. Mason jars and they were planning to discard these and use gallon jars instead to see whether the spoilage couldn't be prevented in this way. Advice was given to the effect that it would be poor policy from the "keeping" as well as from the economic standpoint to make this change since their trouble evidently came from the failure of heat penetration in the 2 quart jars. The processing periods advised in the cold pack method are for quart and pint jars which have a lesser diameter than the 2 quart and thus the heat will more quickly penetrate. It is obvious that the use of gallon jars would not solve this trouble.

[Zae Northrup Wyant].

Fifty samples of soil, silage and manure have been sent upon request to the University of California where they will be analyzed for the presence of *B. botulinus.*

The investigations on foods and fermentations are to be continued by Mr. Robert L. Tweed.

Mrs. Wyant reports further on her soil studies:

SOILS.

One season has passed since undertaking the microbial peat decomposition experiment which employed buckwheat as a crop indicator of microbial activities in peat soil, with very interesting results. In the first place the manure organisms caused a very startling increase in the yield of seed over that of peat uninoculated. Peat alone gave a yield of 3 bushel per acre while peat inoculated with manure organisms gave a yield of 104.8 bushel per acre, peat plus rock phosphate yielded buckwheat seed at the rate of 44.3 bushel per acre, while the same combination plus manure organisms gave a yield of 101.1 bushels per acre.

The various composts used as soil gave very good yields also. Compost A which contained peat, rock phosphate and manure gave a yield of 58.3 bushel per acre. This most probably would have been considerably larger if the plants hadn't been destroyed by rabbits when they were quite large, necessitating the setting in of more plants. Compost B (peat and rock phosphate with compost A as an inoculum) gave a yield of 80.7 bushel per acre, while compost I+M which contained sulfur in addition to the peat and rock phosphate, gave a yield of 94.5 bushel per acre. Thus it was made evident that microorganisms play a considerable part in crop yield.

Either sulfur or rock phosphate or a combination of the two, or sand were found to be desirable adjuncts to peat, The particular type of clay used, however, seemed to depress yields in most cases. The stimulating or depressing action respectively of the various additions seemed to affect the microbial flora, especially particular types.

As a rule composted peat seemed slight better as a soil than raw peat to which compost or other materials was added but this is not sufficiently marked to advise its use in agricultural practice.

From the standpoint of seed yield, it was found to be profitable to compost peat with rock phosphate before using it as a soil or as a fertilizer.

[Zae Northrup Wyant.]

The salient points brought out in these investigations will be submitted as a technical bulletin in the future.

The investigations on microbial decomposition of peat are to be continued under the direction of Dr. Robert M. Snyder.

Research Associate Cooledge, has profited by his advantage in not being required to spend any time in the class room or student laboratory as evidenced by the very satisfactory report of progress which follows:

During the past year I have continued work upon project Adams 3a, which has the following for its object:

(a) A study of methods in use at the present time for determining the bacteriological condition of dairy products.

(b) An attempt to develop new methods where the old are found inadequate.

(c) A study of bacteriological problems relating to market milk by means of tests developed under (a).

Progress made upon this problem has been reported as follows:

1919–1920.

The keeping quality of milk as judged by the colorimetric hydrogen-ion determination (L. H. Cooledge and R. W. Wyant), Journal of Dairy Science, Vol. III, No. 2, March, 1920, Michigan Academy of Science, March, 1920; Local Section of American Chemical Society, April 1920; Local Section of Society of American Bacteriologists, December, 1920.

An improved comparator, Journal of Industrial and Engineering Chemistry, Vol. 12, No. 5, May, 1920.

1920–1921.

Judging the keeping quality of milk by a pH method, laboratory section American Public Health Association at San Francisco, California, Sept. 15, 1920. In American Journal of Public Health, December, 1920.

A new laboratory method of determining the condition of milk. Michigan Public Health Association, Bay City, May 26, 1921.

The two following papers covering work completed during the past year have been completed and are ready to submit for publication:

The colorimetric hydrogen-ion determination as a means of studying biological changes in dairy products, and

An experiment in improving the milk supply of a city milk plant. By L. H. Cooledge, Bacteriological section and O. T. Goodwin, Dairy section.

Problems which I have under way are progressing favorably and give promise of very interesting results.

[L. H. Cooledge.]

The bovine infectious abortion project (Adams, 3b) has continued under the aggressive leadership of Research Associate Huddleson, during the year. Very satisfactory progress on this vital problem is indicated by the following report:

During the past year my time has been largely occupied with the problem in bovine infectious abortion. Additional work has consisted of teaching (Bacteriology 19), examining blood samples (bovine origin) for bovine infectious abortion and bacteriological examination of material from both animal and human origin.

One trip was made during the year to Coldwater, Michigan, for the pur-

pose of giving two herds of dairy cattle the vaccine treatment for infectious abortion.

The following papers have been submitted during the past year:

Studies in infectious abortion. Presented at the annual meeting of the American Veterinary Medical Association, Columbus, Ohio, August, 1920., Journal of the American Veterinary Medical Association, Vol. II, No. 5, 1921.

The accurate diagnosis of bovine infectious abortion. Presented at the annual meeting of the U. S. Live Stock Sanitary Association, Chicago, Illinois, December, 1920. *Vide* annual report for 1920 of the U. S. Live Stock Sanitary Association.

The bleeding of cattle and swine for the blood test for infectious abortion. *Vide* Michigan Agricultural Experiment station quarterly, November, 1920.

The importance of an increased carbon dioxide tension in growing *Bact. abortus* (Bang). Presented by Ward Giltner at the annual meeting of the American Society of Bacteriologists, Chicago, December, 1920. *Vide* Cornell Veterinarian, July, 1921.

The problems in the investigation of infectious abortion which were submitted in the report for 1919–20 have been studied further together with new problems which have suggested themselves in the course of the investigation. Very little progress has been made in one or two of the important problems owing to the limitations of the experimental herd and to the fact that the same animals could not be used for two investigations at the same time.

We have housed, in the experimental barn at the present time twelve cows, fourteen heifers, one bull and two male calves. In addition I have added seven sows for the purpose of conducting investigations in swine abortion.

The problems which are under investigation are:

1. The immunization of cows and heifers against infectious abortion using killed and living cultures of *Bact. abortus* (Bang).

Owing to the large number of factors involved, the solution of this problem is slow. A large number of animals must be employed and experiments repeated before conclusions can be drawn. The data which have accumulated from our own experimental herd while yet few, are very encouraging. Several herds in the State have been treated, but sufficient time has not elapsed for the tabulation of the final results.

2. The routes through which *Bact. abortus* gain entrance to the body. This problem is still under investigation.

3. The bactericidal effect of different chemical agents *in vivo* against *Bact. abortus*. The work on this problem did not progress very rapidly during the past year owing to the employment of the animals in other experiments.

4. A study of the antigenic and pathogenic properties of many strains of *Bact. abortus*. The work on this problem is nearing completion, and will soon be ready for publication.

The specificity of the intradermal test and its value in differentiating between infection and immunity.

This problem has not progressed as rapidly as was planned, owing to the discovery that the *abortin* when injected into the animal would give rise to the development of agglutinating and complement fixing antibodies in the blood of the animal in question. Since the majority of the animals are on immunization experiments, and others are under observation for the return of the above antibodies, the appearance of antibodies from the injection of *abortin* is very misleading and interferes with the correct interpretation of results.

6. The isolation and cultivation of *Bact. abortus.* Since the publication of the late investigations on this problem much thought has been given to its practical application to the study of *Bact. abortus* infections in the udder and in the generative organs. I feel confident that the medium and the method of isolation (atmosphere of increased CO_2 tension) can be improved upon but little. It is true, that in the isolation of *Bact. abortus* from infected milk by means of gentian violet liver agar, there are occasions when a repeated examination fails to duplicate the former findings. A plausible explanation for these results is that there are days when the organisms are not discharged from a *Bact. abortus* lesion in the udder (if such a lesion exists) into the milk. Similar findings are encountered in isolating typhoid bacilli from the feces of carriers or individuals during the disease process. The method of isolation in this case is not condemned as a failure when succeeding examinations fail to give concordant results. To demonstrate the absence or presence of *Bact. abortus* in milk by making repeated examinations, this method is just as satisfactory as the guinea pig method, and much more economical and time saving.

Two new problems have developed and are now under investigation. They are:

1. The observation of heifers which were infected at birth for the return of the infection (*Bact. abortus*).
2. Swine abortion.
   (a) Etiology.
   (b) Susceptibility to *Bact. abortus.* (Bang).
   (c) Prophylactic and therapeutic measures in the control of the disease.

There were received during the year 238 blood samples (bovine) (exclusive of samples from the experimental herd) for the application of the agglutination and complement fixation tests for infectious abortion of which 95 or 39 per cent were positive and the remaining negative to one or both tests.

During the year the following miscellaneous specimens have been received for bacteriological diagnosis.

Source.	Suspected.	Total.	Pos.	Neg.
Bovine	hem. septicemia	4	4	0
Avian	hem. septicemia	1	0	1
Avian	tuberculosis	2	2	0
Porcine	tuberculosis	1	1	0
Bovine	tuberculosis	1	1	0
Human	tuberculosis	2	0	2
Human	typhoid	3	0	3
Bovine	symptomatic anthrax	3	3	0
Avian	bacillary white diarrhea	10	8	2

Three samples of feed were received from different sources and reported as being the cause of the death of live stock. These samples were fed to rabbits and guinea pigs with negative results in each case.

There were prepared during the year seventeen autogenous vaccines for boils. Very favorable results were reported from their use."

[I. Forest Huddleson].

Dr. H. J. Stafseth, Research Associate, was given leave of absence for a year beginning February 1st, 1920. Leave of absence was extended to July 1st, 1921 and he was given the title, Research Associate and Associate Professor. It is our purpose to utilize the half of his time allocated to the

Experiment Station for the study of the miscellaneous animal disease problems that necessarily and continually arise in a State in which animal husbandry is a highly developed branch of agriculture. There are many phases of the abortion problem that are worthy of more attention than Mr. Huddleson can find time to devote to them. Poultry diseases constitute a great menace to a very extensive industry in many parts of the State. Hemorrhagic septicemia, black leg, the intercommunicability of tuberculosis among the various species of domesticated animals and many other animal disease problems await a satisfactory solution.

Research Associate Fabian devotes most of his time to teaching, but he has found time to undertake three minor problems during the spring term:

The first problem was an investigation of the influence of a solution of lye upon the bacterial spores of *B. larvæ*. The lye solution is recommended by the Entomological section for use in connection with American foul brood. It was found that the solution they recommend was of sufficient strength to kill the spores of the above organism. Mr. Ivan W. Parks, a senior student, greatly assisted in this work and we expect to publish the results of the work at an early date.

The second problem was a study of the influence of various kinds of glassware, used for shipping water samples to this laboratory, upon the bacterial count. Every imaginable glass container is used to send in water from over the State. The water is in transit some time as a usual thing especially from the more distant points. Mr. W. L. Mallmann, who has charge of the water analysis, and myself undertook to determine whether the glassware did have any effect and whether it was worth while testing a sample after it had been in transit several days. Our data suggested that the glassware had little or no influence and that there is value in such an examination provided all the other bacteriological requirements are fulfilled, such as taking the sample, etc. Our results will be ready for publication in a short time.

The third problem was a study of the hydrogen-ion concentration of different kinds of glassware when sterilized with buffered and non-buffered solutions. Mr. Ross C. Stull, a senior student, majoring in bacteriology, deserves full credit for the splendid work he did on this problem.

It was while working with sterilized buffered and non-buffered solutions in the laboratory that a greater change was noticed in the hydrogen-ion concentration in the case of the latter than in the former. Numerous investigators have shown that a buffered solution resists a change in hydrogen-ion concentration to a far greater extent than does an unbuffered solution; but to what degree different kinds of glassware influence the hydrogen-ion concentration of solutions sterilized in it has not been studied to any great extent. It was to study the influence on the hydrogen-ion concentration of a buffered and a non-buffered solution when sterilized in various grades and different kinds of glassware that this work was undertaken.

Solutions: For the non-buffered solution triple distilled water was prepared by taking distilled water that came from our laboratory still, and redistilling in the presence of potassium dichromate acidulated with sulphuric acid. Barium hydroxide was then added to this distillate and it was again distilled. The final distillate (conductivity water) was collected, its hydrogen-ion concentration adjusted to pH=7.0, and used for the non-buffered solution. The buffered solution was the standard nutrient broth made by adding 3 grams of meat extract, 10 grams of peptone (difco) and 5 grams of sodium chloride to 100 cc. of tap water. It was sterilized and its hydrogen-ion concentration adjusted to pH=7.0.

Standard solutions: The standard solutions used were prepared according to Clark and Lubs (1), (2). The acid potassium phosphate solution was made from Merck's especially prepared salt ("Sœrensen's potassium phosphate") which had been recrystallized three times in triple distilled water and dried to constant weight at 110–115 C. The sodium hydroxide solution was made from chemically pure material, all necessary precautions being taken to get it carbonate free. It was then stored in a paraffined bottle and care taken to keep it free of CO_2 and moisture. The boric acid and potassium chloride salts were recrystallized several times and dried according to directions. The proper mixtures were made and stored in bottles, the more alkaline series being stored in paraffined bottles.

Indicators: Di brom ortho thymol sulphon phthalein (Brom thymol blue), pH range 6.0—7.6, and thymol sulphon phthalein (thymol blue, alkaline range), pH range 8.0—9.6, were made to 0.04 per cent in 50 per cent alcoholic solution. Phenol sulphon phthalein (phenol red), pH range 6.8—8.4 and Ortho cresol phthalein (cresol phthalein), pH range 8.2—9.8, were made to 0.02 per cent in 50 per cent alcoholic solution.

The color standards: Ten cubic centimeter quantities of the standard buffer mixtures having the desired pH value were placed in colorless glass tubes 1.8 x 15 cm. Ten drops of indicator covering the desired pH range were then added. These tubes were then placed in a Cooledge comparator (3) and were ready to use. The color standards were placed in the front rack of the comparator and 10 cc. of the unknown solution containing ten drops of the proper indicator was placed in the rear rack of the comparator. A compensating blank of water and one of the unknown solution were then inserted in the rear right and front left holes, respectively, of the comparator and the readings made.

PROCEDURE.

Procedure A. New glassware that had never been used was secured from stock and without washing or treating with cleaning solution it was filled with non-buffered conductivity water which had been adjusted to pH 7.0. The glassware was then autoclaved for 30 minutes at 15 pounds pressure. As soon as the water had cooled down to 20° C., 10 c. c. samples of it were taken, 10 drops of indicator added, and the pH value determined in the Cooledge comparator as previously described. This same glassware was refilled four times with non-buffered conductivity water and twice with broth, autoclaved after each time and the pH value determined. This was done to determine the effect of the glassware on the non-buffered solution and to see if the amount of alkali was sufficient to change the reaction of the buffered solution after four times autoclaving with the non-buffered solution. Six different grades and kinds of glassware were treated according to this procedure and were marked sets 1a, 2a, 3a, 4a, 5a and 6a (see tables 1 to 6).

Procedure B. The same procedure was followed with a different set of the same glassware only the glassware was refilled with broth and autoclaved six times instead of four times with conductivity water and twice with broth. It was desired to know if sufficient alkali would be given off by the glassware to change the hydrogen-ion concentration of the buffered solution. Six different grades and kinds of glassware were treated according to this procedure and were marked sets 1b, 2b, 3b, 4b, 5b and 6b. (see tables 1 to 6).

Procedure C. It is common laboratory practice to wash new glassware

with cleaning solution (60 grams potassium dichromate, 60 c. c. sulphuric acid, and 1000cc. water) to get rid of the excess of alkalinity, free it of organic matter, and destroy the resistant spore-forming bacteria, if any are present. Accordingly a third set of the same glassware was obtained from stock and first treated with cleaning solution as follows: The glassware was filled with the cleaning solution, heated 30 minutes in flowing steam, rinsed five times in tap water and once in distilled water. It was then treated as in procedure A. This was done to see what effect the cleaning solution had on the glassware in influencing the hydrogen-ion concentration of the buffered and non-buffered solutions after autoclaving. (Sets 1c, 2c, 3c, 4c, 5c and 6c, tables 1 to 6.)

EXPERIMENTAL WORK.

Soft glass test tubes were divided into sets and marked set 1a, set 1b and set 1c. Each set was run in triplicate as outlined in procedures A, B and C. The results are shown in table 1.

TABLE 1.

No. of times autoclaved.	Procedure A. Set 1a.		Procedure B. Set 1b.		Procedure C. Set 1c.	
	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.
1	Conductivity water	9.8	Broth	6.8	Conductivity water	9.6
2	Conductivity water	9.6	Broth	6.8	Conductivity water	9.2
3	Conductivity water	9.6	Broth	6.8	Conductivity water	9.2
4	Conductivity water	9.4	Broth	6.8	Conductivity water	9.0
5	Broth	6.8	Broth	6.8	Broth	7.0
6	Broth	6.8	Broth	6.8	Broth	7.0

TABLE 2.

No. of times autoclaved.	Procedure A. Set 2a.		Procedure B. Set 2b.		Procedure C. Set 2c.	
	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.
1	Conductivity water	9.0	Broth	6.7	Double dist. water	7.7
2	Conductivity water	8.9	Broth	6.8	Double dist. water	8.6
3	Conductivity water	8.8	Broth	6.8	Double dist. water	7.6
4	Conductivity water	8.8	Broth	6.8	Double dist. water	7.5
5	Broth	6.8	Broth	6.8	Broth	7.0
6	Broth	6.8	Broth	6.8	Broth	7.0

Sets 2a, 2b and 2c, table 2, were hard glass test tubes run in triplicate according to procedures A, B, and C.

TABLE 3.

No. of times autoclaved.	Procedure A.		Procedure B.		Procedure C.	
	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.
1	Conductivity water	9.6	Broth	6.7	Conductivity water	9.6
2	Conductivity water	9.4	Broth	6 8	Conductivity water	9.4
3	Conductivity water	9.3	Broth	6 8	Conductivity water	9.3
4	Conductivity water	8.5	Broth	6.8	Conductivity water	8.6
5	Broth	6.8	Broth	6.8	Broth	6.8
6	Broth	6.8	Broth	6.8	Broth	6.8

Sets 3a, 3b and 3c, table 3, were four ounce druggist bottles run in triplicate and treated according to procedures A. B. and C.

TABLE 4

No. of times autoclaved.	Procedure A. Set 4a.		Procedure B. Set 4b.		Procedure C. Set 4c.	
	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.
1	Conductivity water	....	Broth	....	Conductivity water	7.6
2	Conductivity water	7.8	Broth	6.6	Conductivity water	7.5
3	Conductivity water	7.6	Broth	6 8	Conductivity water	7.4
4	Conductivity water.	7.4	Broth	6 8	Conductivity water	7.4
5	Broth	6.8	Broth	6 8	Broth	6.8
6	Broth	6.8	Broth	6.8	Broth	6.8

Sets 4a, 4b and 4c, table 4, were 300 cc. Erlenmeyer flasks run in triplicate and treated according to procedures A, B and C.

TABLE 5

No. of times autoclaved.	Procedure A Set 5a.		Procedure B. Set 5b.		Procedure C. Set 5c.	
	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.
1	Conductivity water	....	Broth	....	Conductivity water	7.6
2	Conductivity water	7.8	Broth	6 6	Conductivity water	7.5
3	Conductivity water	7.6	Broth	6 8	Conductivity water	7.5
4	Conductivity water	7 4	Broth	6 8	Conductivity water	7 3
5	Broth	6 8	Broth	6.8	Broth	6 8
6	Broth	6 8	Broth	6 8	Broth	6.8

Sets 5a, 5b, 5c, table 5, were large Kolle flasks run in triplicate and treated according to procedures A. B. and C.

TABLE 6.

No. of times autoclaved.	Procedure A. Set 6a.		Procedure B. Set 6b.		Procedure C. Set 6c.	
	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.
1	Conductivity water	9.6	Broth	....	Conductivity water	9.6
2	Conductivity water	9.3	Broth	6.6	Conductivity water	9.4
3	Conductivity water	9.3	Broth	6.8	Conductivity water	9.2
4	Conductivity water	9.3	Broth	6.8	Conductivity water	8.9
5	Broth	6.8	Broth	6.8	Broth	7.0
6	Broth	6.8	Broth	6.8	Broth	7.0

Sets 6a, 6b and 6c, table 6, were Smith's fermentation tubes run in triplicate and treated according to procedures A. B. and C.

TABLE 7.

No. of times autoclaved.	Set 1.		Set 2.		Set 3.	
	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.	Solution.	Avg. pH reading.
1	Conductivity water	9.8	Conductivity water	9.0	Conductivity water	8.6
2	Conductivity water	9.6	Conductivity water	8.9	Conductivity water	8.6
3	Conductivity water	9.6	Conductivity water	8.8	Conductivity water	7.4
5	Conductivity water	9.4	Conductivity water	8.8	Conductivity water	7.4
5	Conductivity water	9.4	Conductivity water	8.8	Conductivity water	7.4
6	Conductivity water	9.4	Conductivity water	8.8	Conductivity water	7.4

Set 1, table 7, was soft glass test tubes filled with conductivity water and autoclaved for thirty minutes at 15 pounds pressure This procedure was repeated six times and the pH reading taken after each time autoclaved. Set 2, table 7, was hard glass test tubes treated the same as Set 1, table 7, while Set 4, table 7, was Erlenmeyer flasks treated the same as Set 1, table 7. All sets were run in triplicate.

DISCUSSION.

It is very evident in comparing the results of the experiments set forth in the preceding tables that there is a decided difference in the hydrogen-ion concentration of the buffered and non-buffered solutions after these solutions have been added to glassware and the glassware autoclaved for thirty minutes at fifteen pounds pressure. This shows that there is alkali in the glassware sufficient to affect the hydrogen-ion concentration of non-buffered solutions to a considerable extent. It also shows that the glassware used still gives off some free alkali even after it has been autoclaved for several times. In the case of the buffered solution the effect of the alkali given off from the glassware on the hydrogen-ion concentration was negligible. In fact, the broth in most cases showed an acid reaction. This is entirely in accord with the recent findings of Foster and Randall (4) who showed that broth in the neutral range (6.6—7.4) undergoes but slight changes in hydrogen-ion concentration. The maximum change being about 0.4 pH and in the majority of cases not over 0.2 pH. The experiments also show that more alkali is given off from soft glassware than from hard glassware.

Treating the glassware with cleaning solution before autoclaving with the buffered and non-buffered solutions had no noticeable effect on the hydrogen-ion concentration of either solution. In each case the hydrogen-ion concentration of the glassware that had been treated with cleaning solution and of glassware that had not been so treated was practically the same. In other

words, cleaning solution didn't affect the amount of alkali given off during autoclaving. However, in some samples of glassware not treated with cleaning solution before autoclaving, it was impossible to get a pH reading, due to some unknown substance which destroyed the action of the indicator. In these cases new samples of the same glassware were obtained and the experiment repeated several times with the same results. Sets 4a and 4b, table 4; sets 5a and 5b, table 5; set 6b, table 6; and set 4, table 7. In working with buffered solutions as nutrient broth, nutrient gelatin, nutrient agar, etc., the alkali given off from glassware during autoclaving has no appreciable effect on the hydrogen-ion concentration but in less highly buffered solutions it may be sufficient to change the reaction so as to confuse results. Levy and Cullen (5) have found the increase in alkalinity from glass containers and ampules sufficient to decompose aqueous solutions of crystalline strophanthin in the concentration ordinarily employed in the clinic.

SUMMARY.

1. Glassware taken from stock, filled with a non-buffered solution as conductivity water and autoclaved for 30 minutes at 15 pounds pressure yielded enough alkali to change the reaction of the conductivity water from pH 7.0 to pH 9.8.
2. The amount of alkali yielded by this same glassware was not sufficient to change the reaction of a buffered solution as nutrient broth. In fact the nutrient broth with a reaction of pH 7.0 before autoclaving had a reaction in some cases of pH 6.8 after autoclaving in this glassware.
3. Soft glassware yields more alkali upon autoclaving than does hard glassware.
4. Glassware treated with cleaning solution still gives off alkali after being autoclaved. In some cases the cleaning solution destroyed or neutralized substances that interfered with the action of the indicator.
5. The practice of adding cleaning solution to new glassware before using is recommended.
6. Laboratory workers should also bear in mind that when working with non-buffered solutions, the alkali yielded by the glassware may be sufficient to change the results considerably.

REFERENCES.

(1) Clark, W. M., and Lubs, H. 1916. Hydrogen electrode potential of phthalate, phosphate and borate buffer mixtures. Jour. Biol. Chem., Vol. 25, No. 3, pp. 479–510.
(2) Clark, W. M., and Lubs, H. 1917. The colorimetric determination of hydrogen-ion concentration of bacteriologic culture media. Jour. of Bact., Vol. II, Nos. 1, 2 and 3, pp. 1–34, pp. 109–136, pp. 191–236.
(3) Cooledge, L. H. 1920. An improved comparator. Jour. of Ind. and Eng. Chem., Vol. 12, No. 5, p. 499.
(4) Foster, Lawrence F. and Randall, Samuel B. 1921. A study of the variations in hydrogen-ion concentration of broth media. Jour. of Bact. Vol. VI, No. 2, p. 160.
(5) Levy, Robert L. and Cullen, Glenn E. 1920. Deterioration of crystalline strophanthin in aqueous solution. Jour. of Expt. Med., Vol. XXXI, No. 3, pp. 267–273.

[F. W. Fabian.]

Assistant Professor Mallmann has continued in charge of the analysis of rural water supplies. We have taken advantage of the Quarterly to give instructions relative to the collection of water samples. His report follows:

During the past year, this laboratory has tested 106 samples of water. Fifty-seven of these samples were sent in from rural districts and represented, in practically every case, farm wells. Fifty per cent of these samples showed pollution, according to the standards adopted by the U. S. treasury department and were reported as unfit for domestic use.

An effort is always made to help the farmer improve his water supply and in several cases, where the farmer followed our directions, the cause of the pollution was removed and the water made safe for domestic use.

Beginning last year, we have required that a full history of each well, accompany the sample. We required this because we believed we could judge a sample more accurately and further, we could give more assistance with less correspondence. The questionnaire has been of greater value than we even anticipated. It has given us the opportunity to judge the water by considering all probable sources of pollution and thus allowing us to give more advise as a means of improving the supply.

Besides testing all samples of water submitted to us, we have also kept close watch on the College and East Lansing water supplies. Both of these supplies are deep wells and have shown no signs of pollution during recent years.

Examinations of the College swimming pool have been made also twice a week. During the fall term, a daily test was made to determine the extent of pollution and the best means of controlling it. A further study will be made this coming fall. At present the water is purified by filtration and chlorinaated lime. The chlorinated lime is added at the rate of 13 pounds per million gallons of water twice a week. The use of chlorinated lime is not very satisfactory and it is recommended that a liquid chlorinator be installed. This form of chlorination has proved satisfactory wherever installed and the cost of installation is comparatively low.

[W. A. Mallman.]

Research Assistant Snyder has pushed the work with the nodule-forming bacteria with carefulness and vigor. He will have charge of the soil investigations (Adams 2c) next year and Frank Davenport (Mass. Agr. College, '21) will look after the pure culture distribution.

Dr. Snyder's report follows:

DISTRIBUTION OF LEGUME CULTURES.

July 1, 1920—July 1, 1921.

	Alf.	S.C.	R.C.	Alsk.	F.B.	G.B.	S.B.	F.P.	G.P.	C.P.	V't'h	S.P.	W.C.	X.	Total.
July	836	96	44	13	....	....	25	....	....	1	50	....	....	....	1,065
August	1,156	176	68	9	....	....	1	....	....	....	477	....	....	....	1,887
September	152	31	19	6	....	....	1	....	....	....	407	....	....	....	616
October 1, to Jan. 1	8	2	....	....	....	....	....	....	....	....	30	....	....	....	40
January 1 to April 1	1,035	719	662	45	....	....	....	34	1	....	20	1	1	....	2,518
April	3,108	2,503	865	80	....	1	15	114	6	....	67	3	....	....	6,762
May	1,324	423	145	5	32	9	1,247	69	3	166	43	....	....	13	3,479
June	1,281	117	37	2	61	....	769	....	....	109	14	....	....	....	2,390
Total	8,900	4,067	1,840	160	93	10	2,058	217	10	276	1,108	4	1	13	18,757

Alf., alfalfa; S. C., sweet clover; R. C., red clover; Alsk., alsike clover; W. C., white clover; F. B., field bean; G. B., garden bean; S. B., soy bean; F. P., field pea; G. P., garden pea; C. P., cow pea; X, miscellaneous".

[Robert L. Snyder]

I wish to take this opportunity to thank you in behalf of myself and the other members of the department for your unfailing courtesy and helpfulness during the past year.

Respectfully,
WARD GILTNER,
Bacteriologist.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE BOTANICAL SECTION.

Director R. S. Shaw,

Dear Director Shaw:

I have the honor to hand you herewith the following report for the Section of Botany for the year closing June 30th, 1921.

The staff has undergone no changes as compared with the close of the previous fiscal year. The pathological work has been under the direction of Dr. G. H. Coons, assisted by Ray Nelson and J. E. Kotila. The physiological investigations have been carried on by Dr. R. P. Hibbard and Mr. H. C. Young. All of these gentlemen have cooperated with me in planning and carrying out the work and deserve great credit for the results obtained.

In the plant disease wrok, progress has been made along the study of cause and control of certain celery diseases, viz:—a Fusarium disease of celery known also as Stunt and Red-heart, for which Dr. Coons and Mr. Nelson have determined the cause and mode of spread and have made progress in developing a disease-resistant strain: Early Blight of celery which has been the subject of investigation under Dr. Coons' direction by L. E. Tisdale, a graduate student.

Mr. Nelson has been following up his work on the breakdown of plants in transit and in storage. He has determined the underlying principles and is

working out methods of control and prevention. He has also been carrying on further investigations with the coniothyrium disease of cherries which caused serious damage in certain localities in Michigan in 1919, and which has proved quite destructive in many parts of the State this year, although practically absent in 1920. He has continued the work on Bean Mosaic and its manner of transmission from plant to plant, and has obtained some very interesting results.

Mr. Kotila has been devoting practically all of his time to the diseases of potatoes, particularly those that are of importance in the Upper Peninsula. For this purpose he spent all of last summer, and has been since early in May this year at the Upper Peninsula Experiment Station at Chatham. The main diseases being studied by him are Black Leg, Mosaic, and Streak. In addition he is carrying on for Dr. Coons, experiments on control of potato scab. Considerable attention has been given by him also to the leaf burn of potatoes, of which the inducing cause is an insect, the potato leaf hopper.

In addition to the foregoing lines of work, minor investigations and experiments have been made in connection with the smuts of grains and a good many other diseases of various crops. In connection with all this work cooperation has been had with the Plant Disease Survey of the Department of Agriculture, Washington.

The physiological investigations have consisted of the following lines of work:

Dr. Hibbard, employing Mr. S. Gershberg as an assistant, has continued the investigations with balanced nutrient solutions, with Marquis wheat as the test plant, while in the field tests with various proportions of fertilizer salts have been made using oats to determine to what extent, if any, such tests will bear out the results obtained from culture solutions.

Dr. Hibbard and Mr. Young have been cooperating with the Horticultural department in the fertilizer experiments in an apple orchard near Grand Rapids. This neglected orchard is being pruned and sprayed in the regular way and has been divided into portions which are given different fertilizer treatments. This department is cooperating in the study of the results by determining the relative rates of growth with the different fertilizer treatments, the assimilation and distribution of nitrogenous compounds, the manufacture and storage of starch, etc. In order to obtain results from which conclusions can be drawn with safety, this work must be carried on for several years more.

Mr. Young has continued his research problem on the effect upon the physiological functions of plants of deficiencies in individual nutrients. The plant on which experiments have been made this past year has been the sugar beet. The preliminary experiments have revealed some very remarkable facts. The work is being continued this summer in the field. It will naturally be many years before the results are complete enough to draw general conclusions.

Aside from consulting with members of the Botanical section upon their problems, I have had but little opportunity to undertake any serious investigations. I began, however, this spring, some work upon the Orange Rust of raspberries and blackberries, which it will take a year or so more to bring to a satisfactory completion.

Respectfully,

E. A. BESSEY,

Botanist.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE CHEMICAL SECTION.

Director R. S. Shaw:

I submit, herewith, a brief report of the work carried on by the Chemical section for the year ending June 30, 1921.

The end of the fiscal year marks the close of our administration of the fertilizer, feeding stuffs and insecticide control laws. The fertilizer law has been administered by the Chemical section, under the direction of the State Board of Agriculture, since its passage in 1885. During that time 34 inspection bulletins, including the current issue, have been published. The use of fertilizers has increased greatly during this time and especially in the past ten years. In 1906 when the first attempt was made to obtain information on this point, it was estimated that the annual consumption was approximately 20,000 tons. Last year (1920) it reached the high mark of 112,616 tons.

The feeding stuffs inspection has been conducted by this section since 1916 and the results of the service that has been maintained since that time show a decided improvement in the quality of the feeds now being sold throughout the State. This is very vividly illustrated by comparing the results obtained on cottonseed meal for the years 1916 and 1920.

Year ending July 1st.	1916.	1920.
No. samples analyzed	144	177
Samples deficient in protein	51.0%	4.7%
Samples deficient in crude fat	6.2%	1.0%
Samples with excess crude fiber	39.6%	2.3%

The insecticide and fungicude law was passed by the Legislature in 1913. Although the fund provided for the prosecution of this work has been only $500 per year we have been able to show some valuable results especially in exposing and driving out of the State several worthless preparations.

During our administration of these control laws, only three prosecutions have been made. One under the fertilizer law and two under the feeding stuffs law.

Much of the success of this work has been due to the efficiency of inspectors, A. H. Teske and E. A. Hebard. It is to be regretted that this change necessarily marks the end of their relations with this section.

In connection with the feeding stuffs inspection, Mr. O. B. Winter has been carrying on some research work in methods for detecting the ingredients of mixed feeds. This work is nearly complete and will be continued in order that the results may be published.

HATCH FUND.

The investigation of the "alkaline permanganate method" which is widely used in determining the quality of the nitrogen in mixed fertilizers has been continued and a large amount of interesting and valuable data obtained. The first report of this work will appear as a scientific paper in an early number of The Journal of Industrial and Engineering Chemistry. This

work is of great interest in view of the fact that there is a very strong sentiment, both among consumers and manufacturers of commercial fertilizers, for a guaranteed statement of the available instead of total nitrogen.

The gasometric method for the analysis of limestone, referred to in my last report, is being further studied with a view to making it suitable to more general application. This method has already been applied to the analysis of baking powders and considerable work has been done in collaboration with other analysts with the object of having it adopted as an official method in the analysis of baking powder by the Association of Official Agricultural Chemists. The results will be published in the journal of that association.

Some cooperative work has been carried on in conjunction with the Entomological section on the reaction of feces. The object of the work is to determine the variation in the reaction and its relation to the control of intestinal parasites.

An investigation of the relation of the reaction and carbon dioxid content of milk and infection with *B. Abortus* has been started in cooperation with the Bacteriological section. Promising results have been obtained, but the work is still too new to warrant a prediction of its value.

ADAMS FUND.

Project 2b—"A Study of the Physical-chemical Aspects of Soil Acidity". Mr. E. J. Miller has spent practically all his time on this project during the past year. Special attention has been paid to the fundamental nature of the phenomenon of adsorption and its bearing on soil acidity. One phase of the subject is nearing completion and results of a fundamental importance have been obtained.

Project 2ba—"The Organic Nitrogenous Compounds in Peat Soils". Work on this project has been continued along lines previously outlined. A scientific paper reporting results of this work will appear in the current volume of Soil Science.

Project 2c—"A Study of the Preparation and Properties of Pure Vegetable Proteins". Work on this project has been confined to preliminary studies of the methods for purifying the necessary reagents that are not procurable from manufacturers.

MISCELLANEOUS.

Two hundred thirty-four samples of a miscellaneous nature were analyzed during the year. This includes the analysis of a number of samples of stock tonics and conditioners not covered by the feeding stuffs law. Several flour mills were inspected during the year for the purpose of securing typical and reliable samples of wheat mill offals, that is, bran and middlings. This was done in cooperation with the Association of Feed Control Officials, the object being the establishment of chemical standards for the wheat by-products.

In conclusion, I wish to call your attention to the fact that all of the members of this section are now free to devote their entire time to research problems, and we stand ready and willing to cooperate with other sections of the Experiment Station on problems that require chemical control. We feel very strongly that all chemical problems should be referred to the Chemical section and we urge your support to this end.

Respectfully,

ANDREW J. PATTEN,

Chemist.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE DAIRY SECTION.

Director R. S. Shaw,

Dear Sir:

The investigations in the cost of milk production were continued by Mr. Riddell, Mr. Kurtz and Mr. Howland until March 1st, 1921, when this work was transferred to the Department of Farm Management.

The studies in the distribution of milk in cities has been continued and a report has been completed giving the results obtained from surveys made by Mr. Stanley J. Brownell in the cities of Lansing, Kalamazoo and Flint.

One other project has been continued by Mr. J. E. Burnett which has to do with a trial in raising calves by use of self feeders. The results are very encouraging and the project will be enlarged and continued during the coming year.

Respectfully submitted,
O. E. REED,
Dairy Husbandman.

East Lansing, Michigan, June 30, 1921.

REPORT OF SECTION OF ENTOMOLOGY.

Director R. S. Shaw,
East Lansing, Michigan.

Dear Sir:

Following is a brief report of the work of the Section of Entomology for the year ending June 30, 1921.

The present year has witnessed no change in the personnel of the Section of Entomology. During the latter part of the summer of 1920, the writer took advantage of a leave of absence to visit the South on a collecting trip, and during the period of three months absence the affairs of the section were ably administered by Professor E. I. McDaniel, Research Assistant in this section.

The animal house is now nearly completed and is in constant use both for the housing of animals under observation and because of the laboratory facilities which it offers. The building was designed and is used wholly to facilitate studies in the biology and control of parasites of food animals, and in this field considerable progress has been made.

The work on the ox-bot is being continued this summer and quite a bit of evidence has been collected and will be checked up later with further experiments.

The studies in intestinal parasites have been prosecuted with diligence and many facts dealing with the microscopic organisms producing disease, and also with the control of these organisms have been established.

Dr. Chandler is at present carrying on some interesting tests in the disinfection of poultry yards for the control of gapes in poultry, and for intestinal parasites.

Grape-berry moth.—For several years increasingly insistant complaints have been coming in, accusing the grape-berry moth of causing serious losses, and in response to this demand a special effort was made to determine some more effective method of control or at least to time the customary sprays, so as to obtain the highest efficiency. In cooperation with County Agent W. C. Eckard, and with the aid of Mr. Hain of this section and Mr. T. A. Farrand of the Section of Horticulture, a good deal of publicity was given the matter and quite a measure of success seems to have resulted, at least so far as the first generation of moths goes.

Grape leaf-hopper.—Following the crusade against the grape-berry moth, in the same part of the State there appeared a wide-spread and serious outbreak of leaf-hoppers, *Typhlocyba tricincta,* and at the present moment the grape growers are just finishing with their spraying in an attempt to gain control over this pest. The proper timing of this spray is important as well, since it is almost useless to apply the spray after the hoppers attain wings and also almost impossible to kill the eggs, so that the time for optimum results is just before the first nymphs attain their wings, which time will be before all the eggs have hatched. For this purpose a combination of Bordeaux and black-leaf forty with soap, seems to be most effective.

Pear psylla.—Late in the winter it became apparent that the pear psylla which had for several seasons been getting worse and worse was going to be more troublesome than ever before. This condition had arisen because of the open winter during which the psyllas had spread all over the farms, in orchards and elsewhere. It was apparent that no spraying operations would be effective if applied against the adult insects since they were scattered so widely, but it was reasoned that the eggs would all be laid on the pear trees themselves and that an egg spray would be especially desirable if such a thing existed. At this time Mr. Dutton of the Department of Horticulture brought in a supply of adult psyllas which were induced to lay their eggs on pear twigs in our cages. These twigs were subsequently treated with several spraying materials and the effects noted during the winter time. Finally lime-sulphur was selected as being the most promising of all the sprays and it was recommended that lime-sulphur, one to seven, be applied just as the blossom buds separate into clusters in the standard varieties. This was accordingly done in a number of cases, through the agency of Mr. Dutton, and apparently with good results, although in many cases Kiefer buds were killed, being at that time too far along for a spray of such a drastic nature. However, the death of the buds in this one variety seems to be less of an evil than the almost certain loss of the crop and possibly of the trees if no chances were taken and no spray applied.

Fruit tree leaf-roller.—An insect considered as a serious pest in the West and one that has been claiming some attention in Michigan lately, in a few localities, is the fruit tree leaf-roller, *Archips argyrospila.* In certain orchards near Muir it has been almost impossible to protect the trees. An attempt was made this year to kill the eggs of this pest by a spray of scalecide put on early, just before hatching. The owner was advised to use it at the rate of one part of scalecide to twelve and one-half of water. The spray was applied at the time when the leaf buds burst and with pretty fair success, since the number of living worms was very much reduced over those of previous years. In this case as in others, egg-masses were collected in the winter and treated in cages here in our insectary, with the various washes which seemed most promising and then the one giving best results was selected for treatment.

San Jose scale.—Counts were made for the Department of Horticulture of living scales in their test of various sprays against the San Jose scale carried on at South Haven. This involves the examination of the insect under the scale, and the determination of its condition in samples taken before the est is applied and likewise the examination of several thousand individuals after the tests have been made and time allowed for the death of the insect. A process demanding much time and very close observation in each case.

The potato leaf-hopper.—The summer of 1920 gave us an opportunity to gain more confidence in the efficacy of Bordeaux mixture in the prevention of hopper-burn of potatoes. The Bordeaux acts in no wise as a killing agent but seems to be the best repellent we have tried thus far. I believe that Dr. G. H. Coons, our plant pathologist, agrees with us in taking this view. Furthermore, the addition of black leaf forty seems to fortify the Bordeaux and to kill outright those immature hoppers that are hit by the spray at the time of application, although the general use of black-leaf forty in a crop like potatoes still remains to be justified by a proportionate money return.

Grasshoppers.—In the northern half of the lower peninsula and in parts of the upper peninsula, continued all through the summer of 1920 to do serious damage. The use of saw-dust bait seems to be effective and to furnish the greatest benefit for a dollar of any treatment although the bait needs to be prepared according to formula. The substitution of coarse crude poison or of arsenate of lead for the white arsenic is bound to result in disappointment; likewise it is easy to use an over supply of salt, which results in failure since the grasshoppers may get salt enough to satisfy their cravings without getting sufficient of the poison. Last year much difficulty was experienced in getting sufficient poison for the work, owing to a shortage at the time of application and many regions were ill supplied. The price of white arsenic also was high, unless purchased in mid-winter. However, the outlook at present is much brighter since blister-beetles whose larvæ feed on the eggs of grasshoppers are appearing in goodly numbers in the regions that have suffered the longest and the Legislature of 1921 has generously appropriated the sum of forty thousand dollars for the purpose of refunding to the counties and townships half of the sums used in the purchase and delivery of the poisoned bait. It remains now for our county agents and extension experts to educate the farmers in the use of the bait.

Codling moth.—During the summer of 1920 an experiment was started looking to the more exact timing of the August spray for the second generation of codling-moth. Cages were established in twelve different stations in various parts of the State and wormy apples collected early in the season were placed therein. The time of the emergence of the adult moths from these cages was noted, both at East Lansing and by the several observers in whose charge they were placed, and the time of spraying to catch the main body of the second generation thus fixed. Furthermore, the time for all parts of the State was computed so far as in our power, by means of isophanes or lines connecting equal events in the State.

These isophanes were corrected so far as our knowledge made possible for elevation and we hope in time to correct for the presence of large bodies of water and for soil conditions, together with other disturbing factors. How-

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Isophanes computed by Dr. A. D. Hopkins of the National Bureau of Entomology on a basis of twenty-five years of observation over the entire United States.

ever, the dates obtained last summer by this method seemed to be fairly correct and the attempt is being repeated along the same lines this year. The following deserve the gratitude and thanks of all concerned because of the work and care made necessary by their voluntarily acting as observers: Mr. Stanley Johnston, South Haven Experiment Station, Van Buren County; Mr. J. O. Hain, Cassopolis, Cass County; Miss Addie Sly, Birmingham, Oakland County; Mr. Minard E. Farley, Albion, Calhoun County; Mr. L. H. Kirkland, Erie, Monroe County; Mr. W. A. Chapman, Bangor, Van Buren County; Dr. Huston, Traverse City, Grand Traverse County; Mr. Frank Smith, Hart, Oceana County; Dr. F. L. Simanton, St. Joseph, Berrien County; Mr. Don Hootman, Graham Experiment Station, Grand Rapids, Kent County; Mr. Walter Wightman, Fennville, Allegan County; Mr. Edward Lyman, Kibbie, Van Buren County; Entomology department, East Lansing, Michigan.

Borer repellant.—For about a century now, fruit growers and entomologists have been in search of something that will repel borers and protect fruit trees more especially, but really all trees as well. Thus far, results have been disappointing but the object to be finally attained warrants the expenditure of much effort even if most of it is wasted. During the season of 1920 a test was made of a new mixture with a hundred or so trees, and during that time our coating seems to have afforded quite a measure of protection. The present season seems to promise equally good results and we are hoping to at least produce something that will protect young orchards from the dreaded flatheaded apple-tree borer.

Greenhouse pests.—The direct control of greenhouse pests has progressed somewhat during the season. Quite a bit of effort has been expended on Aleyrodes and on some of the scale insects with a measure of success.

Household insects.—The work on these pests has been practically at a stand still during the present season. Not for lack of effort but because measures from which we had hoped much, seem to be inadequate. I refer to the control of clothes-moths and carpet-beetles.

Mill insects.—Heat treatments were carried on wherever opportunity offered and usually with gratifying results.

Canker worms.—For two seasons the canker worm has played havoc with our apple orchards especially in the eastern part of the State. Many of the smaller orchards, whose owners are not primarily interested in apples, are being killed out owing to delay in spraying or failure to spray at all.

An enemy of blue spruce, *Olethrentes abietana* has recently been received from Ludington, Michigan, where the small caterpillars are devouring the leaves.

It is difficult to control owing to the close webbing of the twigs inside of which webbed masses the caterpillars feed. The difficulty seems to be that of reaching the creatures with arsenate of lead rather than anything else.

Respectfully submitted,

R. H. PETTIT,

Entomologist.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE FARM MANAGEMENT SECTION.

Director R. S. Shaw,

Dear Director Shaw:

During the year the Farm Management section was organized and it was arranged to carry on certain work in the Experiment Station.

Mr. F. T. Riddell, who has been working in the Dairy department on the cost of milk production was transferred to the new department. Also appropriations where made by the State Board of Agriculture to support five route men. These route men visit each of twenty-five farmers once each month and weigh feed and milk and assist the farmer in taking an inventory and keeping his accounts. From this data accurate material on farm management is being secured. Work is being carried out on one hundred farms. One route is located in Lenawee county and is made up of farmers who are engaged in the feeding of steers and lambs; another route is located in Wayne and Lenawee counties and is made up of farmers who are selling whole milk in the Detroit market; still another is made up of farmers in Jackson and Shiawassee counties and the fourth route is made up of farmers in the potato growing section of the State, and contains only farms on which at least five acres of potatoes are being grown. These farms are about equally divided between Montcalm, Antrim and Emmet counties.

Very truly yours,
H. M. ELIOT,
Professor of Farm Management.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE FORESTRY SECTION.

R. S. Shaw, Director,

Dear Director Shaw:

I herewith submit a brief report of the work of the Section of Forestry for the year ending June 30, 1921.

The study of the rate of growth in diameter, height and volume of forest plantations which we have been carrying on for the last two years was finished and the report was completed during the year.

The experimental work on sap flow in the College sugar bush was continued and careful records were kept of the costs and of the amount of fuel used per gallon of syrup. The results of this work have been published from time to time in the Experiment Station Quarterly.

We now have five years' data on the experimental basket willow plantation at Spring Lake. Last year the profit from this plantation was excellent but this year owing to the stagnation of the furniture market, they were unable to sell the rods. It is possible, however, that the rods may be stored and sold next year. The plantation has shown a steady increase in net profit since the second year and with ordinarily good market for the rods it should prove a success.

Last summer we started a study of natural reproduction of hardwoods on cut-over lands in the northern part of the State. A number of sample plots were established on burned-over land under various conditions and it is hoped to continue this work next year, at the same time remeasuring the plots that were put in last summer.

A number of minor projects were also carried on during the year, such as studies of methods of preventing the damping off of coniferous seedlings in the first year seed beds, the tolerance of hemlock transplants with a view to their use for underplanting hardwood stands, and studies of the control of the form of trees. The work has progressed very satisfactorily.

Respectfully submitted,

A. K. CHITTENDEN,

Forester.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE FARM CROPS SECTION.

Director R. S. Shaw,
East Lansing, Michigan.

Dear Director Shaw:

The placing of more land at the disposal of this section has enabled us to undertake many new projects and to increase the size of fields, planted to new and improved crops varieties, for increase purposes.

The varietal testing and improvement work under the direction of Professor F. A. Spragg, assisted by Mr. E. E. Down, has made great advancement. In addition to the great range of crops previously handled, improvement work with potatoes and wax beans has been undertaken.

Professor Spragg's accompanying letter reports the progress in plant breeding work in detail.

The comparative test of short season hay crops, such as millets, sudan grass, soybeans, sorghum, etc., is in its third year and sufficient data will be available for the issuance of the Experiment Station publication after the coming year's results are determined. Professor C. R. Megee is in direct charge of this experiment, also the work with soybeans.

In cooperation with Dr. R. S. Snyder of the Bacteriology department, Professor Megee carried on a demonstration of effective inoculation of soybeans with proper culture. At this time the half of the field of one and one-half acres, which was inoculated, carries a vigorous growth of soys, deep green in color. The other half of the field is of a light yellow color and shows much less vigorous growth.

The tests of alfalfa and clover varieties were greatly enlarged by an arrangement with Mr. J. W. Nicolson of the Farm Bureau Seed department, who furnished samples of the numerous alfalfa varieties purchased in the west by the seed department of the Farm Bureau for distribution in Michigan.

Dr. A. J. Pieters, in charge of clover investigations of the U. S. D. A., also furnished us with numerous samples of foreign and native grown alfalfas and clovers.

An increase of five and one-half acres of Hubam clover was planted for seed purposes, and an extensive experiment begun in order to test the value of

Hubam for forage, green manuring, and pasture purposes. A thick seeding has resulted naturally from seed which shattered from the Hubam crop harvested in the fall of 1921 for seed. Apparently this annual sweet clover will prove of value in the improvement of light and infertile soil and as a pasture and hay crop.

By arrangement with Mr. Ralph Hudson of the Farm and Horse department, large fields of from ten to fifteen acres, were planted to selected Duncan, Golden, Glow, and Duncan-Golden Glow cross corn. These fields were all well isolated and will furnish several hundred bushels of each variety of highly improved seed for distribution from the College. The seed used in planting these fields was secured by careful selection from small increase fields planted from the best strains of the 1919 ear row work.

Mr. J. R. Duncan is handling the ear-row work and corn varietal tests in the field. Mr. Duncan is also associating with Mr. J. G. Willier of the United States Department of Agriculture on popcorn improvement work.

Over-state varietal tests, which are being planted by Mr. Duane Rainey, have furnished objectives of many field trips planned by county agents. Valuable information has been secured regarding the comparative yields of varieties and adaptation of crops. This work includes the following tests well distributed over the State: wheat, oats, barley, rye, corn, soybeans, alfalfa, millets.

The members of the Farm Crops section appreciate the aid of representatives of the following Experiment Station sections and the United States Department of Agriculture, county agents and farmers in the field:

Mr. Ralph Hudson of the Farm and Horse department has greatly facilitated our work by interchanging labor and by aiding us when work in the field was pressing. Mr. Hudson has entered upon arrangements which have made possible the increase of superior varieties in a large way on the Station farm.

Professor H. H. Musselman of the Farm Mechanics section has rendered us great service by joining us in a cooperative arrangement, which provides ample tractor power and equipment for our field work, threshing operations, etc.

Professor O. E. Reed of the Dairy section is cooperating in determining the value of sweet clover and the new Hubam by pasturing off allotted areas, and feeding hay taken at different periods to dairy stock under test.

Director R. J. Baldwin has made cooperative arrangements which have made possible the planting of crop experiments at widely distributed points over the State. This type of work is of the greatest importance in determining crop adaptations.

Dr. E. A. Bessey and Dr. G. H. Coons of the Botany section are furnishing careful disease inspection of bean and potato varieties.

Mr. Robert L. Davis of the United States Department of Agriculture, Department of Fiber Investigations, has extended his testing work with fiber flax strains and planted unusually large increases of superior strains. His work occupies approximately five acres of the land allotted to this section.

Mr. J. G. Willier of the U. S. D. A., Office of Cereal Investigations, has contributed many varieties for our popcorn varietal tests and is cooperating in popcorn improvement work.

Mr. Wilbur Brotherton of the U. S. D. A., Bureau of Plant Industry, has planted extensive varietal tests of beans from native and foreign sources.

Dr. A. J. Pieters of the U. S. D. A., in charge of clover investigations, has furnished us valuable help in providing foreign grown clover and alfalfa seed for our tests.

Mr. H. N. Vinall of the U. S. D. A. is actively cooperating in the work with field peas and has furnished many varieties for planting at this Station and at the Chatham sub-station.

I particularly desire to express the great appreciation felt by all members of this section for the support and guidance extended to us by the Director, the President and the State Board of Agriculture.

Yours very truly,
J. F. COX,
Professor of Farm Crops.

Professor J. F. Cox, Michigan Agricultural College,
East Lansing, Michigan.

Dear Sir:

The following is a brief report of the plant breeding work for the year ending June 30th, 1921. To save space, a list of the plant breeding projects for the year are checked off in a table. It has seemed best to include brief outlines of past results and future plans. The results of one year, when isolated from the results of other years and from future possibilities, mean little to anyone.

PLANT BREEDING PROJECTS 1921.

The crop and kind of work.	Varietal testing.	Beds and progenies.	Plant-rows.	Milling and baking.	Increasing.	Crossing.	Segregation.	Selfing.	Rate of seeding.	Winter hardiness.	Date of seeding.	Disease resistance.	Disease freeing.	Clonal selection.	Isolation.
Alfalfa	√	√	√		√	√	√			√		√			
Barley	√	√	√		√		√						√		
Beans	√	√	√		√		√		√			√	√		
Clover		√	√				√			√					
Corn	√	√	√		√	√	√	√							√
Crimson clover		√								√					
Hemp		√					√								
Hubam clover		√			√		√			√					
Oats	√	√			√								√		
Potatoes		√										√	√	√	
Rye	√	√			√		√	√			√		√		√
Sugar beets	√	√	√				√	√							√
Sunflowers		√	√				√					√			√
Timothy	√													√	
Wheat	√	√	√	√	√		√		√	√	√		√		

The principal part of the alfalfa work is a nursery containing 10,400 individual plants, with which individual hay and seed records are being kept on each individual plant. This work has been running since 1906, and has resulted in the entire elimination of the old fashioned type, having a single tap root and a crown that branches above the surface of the ground. This

latter type has not been selected against as such, but has proven to be unhardy as well as having poor producing plants. The highest yielders of hay and seed from the best producing progenies have become the mothers of the next generation. Those that have survived the test, being hardy and productive, are all low crowned plants, branching below the surface of the ground. They also have a branching root system.

Visitors often ask, "What variety of alfalfa does the test show to be best?" This is a hard question, because the nursery shows as much difference among the various strains within a variety as it does among varieties. One strain of Grimm, for instance, may easily yield twice as much as another strain of Grimm. It may grow twice as tall, and be very much more resistant to leaf spot, a disease that turns the crop yellow. The fact is that all of the hardy productive types have originated in crosses between yellow flowered Siberian alfalfa and purple flowered southern types.

As seed has been distributed from this alfalfa breeding work, the problem now is to develop a Michigan seed industry. A start is being made in that direction, with Hardigan alfalfa.

As the results with spring barley have never been satisfactorily reported, and as a new barley varietal series has just completed a three year period, it seems proper to give this work a little more than a passing notice. The historical portion of Circular No. 32 (printed in 1916) outlines the first ten years of work with spring barley, and summarizes them with the statement that "the best spring barley that this investigation has been able to find is producing less feed (pounds of grain) per acre than the high grade varieties of oats". This is compared with the Alexander, Worthy, College Success and College Wonder oats, that had then been introduced as new commercial varieties from the breeding work of the Michigan Agricultural College.

Be this as it may, there is a demand for barley for certain feeding operations, where oats are considered unsatisfactory. Thus, in 1918 these investigations introduced two new varieties of barley. These are the Mich-two-row (No. 02708) and Michigan Black Barbless (No. 31604). They originated in individually selected plants of 1910 and 1913 respectively, and have proven to be successful commercial varieties.

The earlier varietal testing work (up to and including 1916), located a number of promising varieties that needed purification. These were placed in selection plats in 1917, where the individual seeds were planted five inches apart each way. The selected plants became mothers of plant-rows in 1918. This series included forty-eight new strains and the checks [a standard variety planted every fourth row] making the series sixty-five plant-rows. Those that compared favorably with the checks were retained and entered the varietal series April 5, 1919. Fortunately this was gotten in early, as protracted rains prevented the planting of any more grains until May first, resulting in failure for the late planted series. The results of this series during the years 1919 and 1921 follows:—

BARLEY VARIETAL SERIES 1918-1921.

Yields are expressed as per cents of Michigan-Two-Row—Each result is the average of duplicates.

Strain.	Variety.	No. of rows.	1919.	1920.	1921.	Ave. %.	Bus. per acre.
72228	Crawford (barbed)	2	101.89	99.08	106.83	102.60	41.9
02708	Michigan-two-row	2	100	100	100	100	40.8
72213	Crawford (rough)	2	76.76	97.82	107.85	94.14	38.4
72113	Swedish golden	2	99.30	100.55	78.17	92.67	37.8
72231	Crawford (barbed)	2	91.89	95.97	87.40	91.75	37.4
72209	Crawford (rough)	2	89.46	101.11	83.08	91.22	37.2
72117	Swedish golden	2	80.95	99.67	88.18	89.60	36.6
72523	Mansbury	6	97.37	88.76	80.32	88.82	36.2
72319	Charlottetown	2	72.09	97.30	94.31	87.90	35.9
72203	Crawford	2	72.97	101.44	84.52	86.31	35.2
72413	Wisconsin, No. 9	6	71.16	99.88	84.63	85.22	34.8
72439	Wisconsin, No. 9	6	83.02	83.92	86.10	84.35	34.4
72120	Swedish golden	2	71.19	99.55	78.06	82.93	33.8
72433	Wisconsin, No. 9	6	82.14	80.60	84.87	82.54	33.7
72457	Wisconsin, No. 9	6	75.41	90.73	81.15	82.43	33.6
31604	Michigan-black barbless	6	*75.65	*80.36	88.21	81.40	33.2
72539	Mansbury	6	78.82	89.30	73.93	80.68	32.9
72453	Wisconsin, No. 9	2	66.07	80.12	94.37	80.19	32.7
72518	Mansbury	6	72.18	80.54	77.53	76.68	31.3
72546	Mansbury	6	65.14	78.12	73.07	72.11	29.4

*These two results were obtained in the years 1917 and 1918. This variety was not in the 1919 series and the seed did not germinate well in 1920.

Two of these strains have become commercial since 1918. The results show that the check (Michigan-two-row) has found only one worthy competitor and this is a strain picked out of a variety (Crawford) that varied considerably in yielding power. On the other hand the Michigan Black Barbless has not proven to be a good yielder in these tests, but farmers like it because it is smooth awned. The Crawford has two strains with awns that are not sharply barbed, being considered simply rough awned. These are No. 72213 and No. 72209. All other strains in this test have barbed awns. It is noted that more than half of the above varieties and all of the highest yielders are two-rowed barleys.

The future interest in barley breeding seems to center around a cross between the Michigan-two-row and Michigan Black Barbless. This cross was made in 1916, and since that time has been running in the progeny selection plats. The result is that a number of white smooth awned types have been obtained. Some of them are two-rowed and some of them six-rowed. As soon as they can be increased they will be placed in varietal series. If a good yielder can be found among them it will be increased. Such a barley will easily take preference above all barbed barleys.

A bean bulletin is at the printer's and will be in the hands of growers before this report is printed. It reviews the bean breeding work to date. The results show that the old strains of Robust now in the hands of growers have, as a rule, been so badly mixed that many of them are no more productive than the common varieties.

A new strain of Robust (No. 40520) will be introduced under the name of the Improved Michigan Robust in 1922. It is now being increased for that purpose. The results show that it yields one and a half times as many beans as the Early Wonder, on an average of three years' tests at the Michigan Agricultural College.

The future of the bean breeding work seems to center around varieties that are resistant to anthracnose and blight. The former type of resistance is coming from a cross made in 1916, and the Improved Michigan Robust is considerably resistant to blight, enabling it to retain a much larger portion

of its leaves than other varieties. No doubt selection work within this new variety will gain still greater resistance. A great aid to selection wôuld come if the plat to be selected can be sprayed with the blight organism at frequent intervals. The plants that survive such an epidemic could be increased and subjected to the same treatment again. By this means the indications are that great resistance may be hoped for. This work is under way.

The clover work indicates that the ordinary red or June clover has little to recommend it in a breeding way and probably will be replaced in time by other types. Alfalfa has crowded out red clover in the west, whereas twenty years ago it was in the experimental stage, just as it is now in Michigan.

The work with Hubam clover enabled the Michigan station to distribute 42 bushels of seed during the past winter and spring. Most of this is being grown for seed.

There is a type of Hubam that survives the winter. It is not the ordinary biennial, as it ripens its seed almost all at once. Some of these plants were transplanted from the general field this spring. That field was known not to have any biennial sweet clover. It is therefore known that the mother and grandmother of these plants produced seed in their first year, and it is thought that these plants did. If a type of sweet clover can be developed that will produce seed and survive, that is more than the old fashioned biennial ever did. Seed will be saved from these plants individually and a nursery set out in 1922 to determine these points and produce such strains if possible.

There is a demand for breeding work with crimson clover. Two types of work have been suggested. One is to develop a summer annual and the other a hardy winter annual. A beginning has been made with this work in 1921.

The corn work is continuing much as has been reported. It is evident that progress in ear-row breeding work requires that the ears (going into the test) be selfed. Then it is easy to fix types. Those showing a recessive character will breed true in the future, and among those that show dominant characters the ear-row test will enable the breeder to locate the homozygote. Remnants are always saved and returned to for increases. Wherever possible strains that breed true to definite characters are crossed by inter-rowing and detasseling. The purpose is to return any vigor that may have been lost through selfing. Then if the cross can be increased and selected one year, before selfing is again undertaken, recombinations of characters enables the breeder to obtain more nearly what he desires for ear-row work again.

The hemp breeding work is continuing through the cross made in 1920, between two strains of hemp that had been separately selected for three years. One of these was very early but not a good type. The other was a good type but very late. The selections are being made so as to include quality and earliness.

The oat work has produced five new high producing varieties. During the past three years, the oat varietal series has been discontinued, to allow space for the barley varietal series. During the interval a new set of individual plant selections have been increased and placed in a new yield series in 1921. The space available for the testing of spring grains will not allow a large varietal series of both barley and oats at the same time, but in addition to a yield series with one of these grains the selection plats can be maintained for both types of grain.

Potato breeding is being taken up by the Farm Crop section at Michigan Agricultural College for the first time. It has been under way at the Upper Peninsula Station during the past two years. The first work is disease freeing. The inspection forces of Minnesota, Wisconsin, Michigan and New

York, have very kindly cooperated in the finding of the best growers of the most promising varieties. Approximately sixty selected half-pound tubers were obtained from seventy-six sources and small quantities came from twenty other sources. These lots were reselected at East Lansing to obtain the best for planting. After treating and drying, each potato was cut into four pieces at planting time. These four pieces were planted in adjacent hills, called tuber-units.

The potato improvement work at Chatham and East Lansing is cooperative with the members of the Department of Botany, who take care of the disease phases of the work. They treat the tubers before planting, pull out all the tuber-units that develop constitutional diseases, and attend to the spraying. The year of 1921 is considered a quarantine year, during which time all disease types are to be rogued out. Tuber-units will be selected at harvest, to continue in plant rows for 1922. The checks in that series will be a tuber line selected and increased at Chatham.

During the following three years, the plans are to pool the selected strains from the two Stations and grow duplicate varietal series at the two Stations. Then the best ones will be ready for increase and distribution.

During this time the plan is to make crosses between promising strains and compare the new seedling lines for disease resistance and good production of potatoes with desirable quality.

The new rye bulletin, that is now at the printer's, gives a good outline of results with Rosen rye. A varietal series will be planted in the fall of 1921. This series will include the most highly recommended varieties throughout the country, together with the strains of Rosen rye in the hands of the Michigan Crop Improvement Association. Also it is planned to plant a series of spring ryes in the spring of 1922.

Rod-row series will include samples from all the growers receiving inspection in 1921, in addition to about a hundred lots coming from individually selfed heads and plants collected in 1919 and 1920. These lots were caged in a wheat series in 1921. The purpose is to plant a portion of the seed and save a remnant. The results will indicate the more desirable remnants to be used in future rye breeding work.

The work with sugar beets is considerably increased in 1921. The most highly recommended lots of seed in this country and Europe have been obtained to place in a varietal series. The selfed seed of 1920 entered progeny rows in 1921 and other beets are isolated for selfing purposes.

The other lines of work are indicated in the table and most of them are continuing much as usual. The wheat work is becoming so extensive as to over-crowd the space allotted to it. The new varietal series, started in the fall of 1919, was so badly drowned in the spring of 1920 as to make the results undesirable. A good set of results are obtained in 1921, but this series should run two more years to give desirable averages. Meanwhile new lots coming up through the smaller series and plant-rows demand space. Some new wheats will be increased during the next year.

Respectfully submitted,
F. A. SPRAGG,
Plant Breeder.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE FARM MECHANICS SECTION.

Director R. S. Shaw,

Dear Sir:

Following is a report of the experimental and investigational work of the Farm Mechanics section for the year 1920–21.

The nature of the over-state investigational work which is a part of the program of this section, has been found difficult to carry out. The men who are on part time on the Experiment Station pay-rolls find their time limited for field work. While this is true on account of teaching schedule, I feel that greater practical returns can be had from this line of effort than from many laboratory experiments which we might make.

DRAINAGE AND DEVELOPMENT WORK.

In experimental work in drainage there is splendid opportunity to make a study of performance of drains on the systems installed under the supervision of the extension specialist in drainage in St. Clair county. A contract is practically closed with the Department of Rural Engineering, United States Department of Agriculture, whereby cooperative studies will be made in drainage. Some experimental work in the Upper Peninsula should also be done on the performance of tile drains in their particular soils and climate.

In view of the work on land clearing which is being started in the Upper Peninsula, some figures should be kept on the essential features and cost of land clearing. It is not felt that an exhaustive study of costs would be profitable because of the widely varying factors entering into individual problems.

FARM BUILDINGS AND CONVENIENCES.

A study of potato warehouses for cooperative associations has been made and plans and specifications drawn. Many new building plans have been developed although the work has been delayed through lack of a draftsman. An exhaustive bulletin on farm barns is nearing completion. As indicated by correspondence the interest in the septic tank for farm use is increasing, and plans have recently been developed for a septic tank suitable for summer camps, resorts and county fairs. In cooperation with the Farm Management department surveys will be made the coming year on approximately 100 farms of the farm house, farm kitchen, and farm conveniences.

TRACTORS AND POWER MACHINERY.

Investigational work has been in progress during the past year with a view to determining the cost of the various farm tractor operations. For cooperation in this work we are largely indebted to Professor Eliot and Mr. Riddell. Plans are now under way for the testing of oil engines, particularly those engines using the heavier fuels such as kerosene, distillate and fuel oils.

In farm machinery, emphasis has been placed on trying out the new machines and new features on machines coming on the market.

Yours respectfully,

H. H. MUSSELMAN,

Professor of Farm Mechanics.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE HORTICULTURAL SECTION.

To Director R. S. Shaw,
East Lansing, Michigan.

Dear Sir:

The past year was characterized by quite an expansion in the experimental work in horticulture which has been facilitated by the services of Dr. N. L. Partridge who joined the department, September 1, 1921, and by Mr. R. E. Marshall who began his services, September 15, 1921, and who is giving part time to experimental work; also by the greater facilities afforded by the acquisition of the Graham Horticultural Experiment Station property.

The fundamental problem in Michigan horticulture today is that of increasing the production and quality of our bearing orchards and vineyards. It is rather a problem of increasing the production of the present acreage than of promoting increased plantings. With this idea in mind this department is concerned largely in experimental work that will lead to the production of larger and better crops of fruit from present plantings. Spraying, pruning, fertilizing and plant selection are lines of particular importance from this standpoint.

During the past year the College has rented on a five year contract, five acres of a vineyard on the farm of Mr. Carl Buskirk, Paw Paw, Michigan, for experimental work in fertilizing and pruning grapes. This project was requested by the Horticultural Experimental Committee of the State Horticultural Society, there being a pressing demand at the present time for information on the proper fertilization of grapes and the most ideal system of pruning in relation to fertilization. Much of the time of Dr. Partridge has been spent, since the beginning of the growing season this spring, making general studies of these projects, a detailed outline of which together with the other experimental projects of this section have already been presented to you.

The section has been very largely interested in experimental projects in relation to the fertilization of bearing orchards. Some forty or fifty fertilizer tests were carried on in cooperation with the extension force in Michigan orchards the past year. The outstanding fact in relation to these results was the beneficial effects of quickly available nitrogenous fertilizers applied early in the growing season to nearly all of the orchards where efficient cultivation was practiced. In the orchards where trees were in sod practically no results were obtained from the use of fertilizers. It is the opinion of the writer that this was due to the dry weather which characterized the growing season. There was, therefore, an insufficient supply of soil moisture in uncultivated orchards to make this fertilizer available to the trees. We believe that by these tests throughout the fruit sections we are demonstrating the general need of fertilizing fruit crops to increase production and also the necessity of orchard cultivation or mulching to insure a bountiful supply of soil moisture.

As a result of these tests the past two years, our growers are using far more fertilizer than ever before and we expect to see this practice greatly increased in the near future. These fertilizer tests are made not simply to induce fruit

growers to use commercial fertilizers, but to direct them as to the kinds of fertilizers that will give the best results and the amounts that should be used.

As in the past the work of Mr. W. C. Dutton has been largely along the lines of spraying and dusting. Laboratory studies were made during the winter months on the various brands of spray materials offered on the market, together with their physical characteristics. Studies were made on the use and value of spreaders in sprays, and field tests of spreaders are being made the present season. A brief summary of the results of the work along spraying lines for the season of 1920 follows:

Dusting and spraying apples.—Sulphur dust gave as good control of apple scab and codling moth as standard liquid sprays. Variety: Grimes golden, location: South Haven.

Dusting and spraying pears.—Two orchards of Bartlett: location, South Haven. The average results in two orchards were about equal for scab control. Physical condition of dusted foilage much superior to that sprayed with lime-sulphur 1 to 40 or 1 to 50. An extra application (pre-pink) was of value in controlling scab. This application probably is very desirable where scab is prevalent.

Copper sulphate dusts.—(Sanders dust) did not give satisfactory control of scab on either apples or pears. Location: South Haven.

Peach dusting and spraying.—Dusting for leaf curl with soluble sulphur and Bordeaux dusts did not give satisfactory results. Results consistent with those of 1919.

Summer dusting of peaches devoid of definite results because of absence of injury on checks. 90–10 and 80–10–10 sulphur-lead dusts were entirely safe on peach foliage. Copper sulphate dust was also safe. Location: Saugatuck.

Plum dusting and spraying.—Emphasis on rot control. Lombard variety; checks very bad; fruit nearly total loss on some trees. Dusted and sprayed apparently equal at harvest with very little rot on either. Sprayed trees received last application of lime-sulphur (1-40) about one month before harvest. Sulphur dust (straight sulphur). applied then, also one week before harvest. *Holding quality of dusted fruit decidedly best.* Location: South Haven.

Dry lime sulphur on duchess apples.—Results were consistent with those of previous year. Dry lime sulphur regardless of strength used did not give results equal to lime-sulphur solution (1 to 40) although no definite plots were arranged on this point, the results indicate very strongly that a pre-pink application is desirable to prevent an early infection of scab which frequently occurs on duchess. Location: South Haven and Grand Rapids.

Cherry dusting and spraying.—Location: Traverse City; varieties: English Morello and Montmorency. Lime-sulphur, 1 to 40, Bordeaux 4–4–50, sulphur dust and copper sulphate. Injury on Montmorency checks not severe but control with all materials was satisfactory. There were some slight differences. On Morello, checks practically defoliated. Very little leaf spot on Bordeaux, a little on lime-sulphur plot, more on sulphur dust plot and still more on copper sulphate dust plot.

Considerable injury on foliage of both varieties developed from the use of Bordeaux. The results indicated that lime-sulphur should be used at the rate of one and one-half gallons to 50 to give best control.

Grape and potato dusting.—Copper sulphate dust used on them but no definite results obtained because of lack of any injury on checks controllable by materials used. Grape foliage dusted was in much better condition than where sprayed. The sprayed foliage showed considerable spray injury which probably developed in connection with the leaf hopper injury.

The experimental work of R. E. Marshall is along the lines of plum and apple pollination studies, fertilizer experiments with small fruits and pruning experiments with tree fruits. This work has just been started the present season so that there is nothing in this line to report upon at the present time.

Excessive demand for grape plants the past two seasons has lead to a demand for investigations of the best methods of propagating grapes from hardwood cuttings. During the past winter Mr. Stanley Johnston did considerable work along this line testing out different methods of storing and handling grape cuttings to induce efficient callousing. A detailed report of this will be made before next spring to prevent the severe losses that have been experienced the past season by the growers in trying to root these cuttings.

Tests were made under the direction of Mr. H. C. Moore of different varieties and strains of canning peas, especially in reference to their resistance to root rot and production.

In cooperation with Mr. C. W. Waid of the Extension division, variety tests and tests of selected strains of potatoes were conducted as in previous years; also a number of fertilizer tests with different forms of fertilizers and with different distances of planting, but due to the exceedingly dry weather the results of these tests in several parts of the State were not conclusive.

The work on bud selection and performance record work with Baldwin apples as previously reported was continued and the work will probably be concluded this year. The bud selection work in the duchess orchard on the Wilson farm at Benton Harbor, Michigan, was concluded at the end of the season. With these records at hand a study was made in the orchard as to the condition of the trees to see if the differences in the productional records of these trees could be ascribed to any condition of the environment or to any physiological condition of the tree itself. A careful study of the trees in this manner showed that in each case the differences in production could be ascribed to poor drainage, root gall, girdling or to some physiological condition influencing production rather than to an inherent character of the tree.

During the fall Mr. Dutton made studies of grape vines endeavoring to obtain vines producing a larger and better fruit and being expecially productive and vigorous. Such vines as seemed promising were staked in various vineyards in Van Buren county and records will be taken upon them the coming fall.

Respectfully submitted,
C. P. HALLIGAN,
Horticulturist.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE GRAHAM HORTICULTURAL EXPERIMENT STATION.

To Director R. S. Shaw:

Dear Sir:

It is a pleasure to report the development that has taken place on the Graham Horticultural Station grounds during the past year. Since the last report the old farm house that was on the property when purchased has been

cut into two parts, each being moved to the rear and reconstructed into a farm cottage. We now have two farm cottages in excellent condition and practically finished except for the water and plumbing fixtures which are now being installed.

Much work has also been done in developing the landscape feature of the grounds. The wagon shed, corncrib and other secondary farm buildings have been moved making a more ideal and convenient arrangement. Much work has been done in subduing the farm and developing it into a sightly State experimental property.

Since the last report we are happy to state that the State Board of Agriculture has purchased an adjoining fifty acres of land making the Station now one hundred acres in extent. The original fifty acres of this property including the barn and cottages is now pretty well planted except that portion near the rear boundary which is low ground and has not been cleared and developed. All of the acreage adapted for fruit planting on this division has been set to trees and is now devoted to the following experimental projects:

Project 1: Young duchess apple orchard to test the relative value of alfalfa sod mulch, grass sod mulch and cultivation with cover crops, in growing orchards and their relative nitrogenous requirements.

Project 2: A cultural project with young apple trees to compare the effect of various systems of culture. In this project:

Plat 1 is to be plowed early in the spring and clean cultivation will be given until the cover crop is seeded again about July 20th.

Plat 2 is to be kept in clover as continuously as possible. A mulch of straw is to be kept around the trees as far out as the tips of the branches, and the clover on this plat will be mowed for hay and removed.

Plat 3 seeded to alfalfa with the trees mulched with straw as plat 2, and the alfalfa cut and removed from the orchard.

Plat 4 same as plat 3 except the first cutting each year of alfalfa will be used for a mulch about the trees while the other cuttings are to be removed from the plat.

Plat 5 to be treated exactly as plat 4 except that this treatment is to be supplemented by an application of nitrate of soda to the trees early in the spring.

The fundamental object of this test is to see if fruit growers can produce young apple orchards by continued use of intervening spaces among the trees for producing such crops as alfalfa, without proving deterimental to the growth of the trees until they come into bearing.

Project 3: Apple training and pruning experiment. To ascertain the best methods of pruning trees at planting time and each succeeding year. Six standard varieties of trees were selected to plant in the spring of 1919, 20 feet apart each way. The first row of each variety had the roots and tops pruned heavily when set and were to be pruned during the dormant season each succeeding year as commonly practiced. Row 2 of each variety was not pruned at planting time except to reduce the scaffold limbs to at least five and no pruning is to be done after setting until the trees come into bearing. Row 3 of each variety had little pruning of the tops when set, the scaffold limbs being reduced to five or less but with no heading back of the scaffold limbs. These rows are to have a little pruning the first half of July. Row 4 of each variety had a little pruning of roots and tops when set with the scaffold limbs reduced to five or less. These rows are to be pruned frequently

during the growing season, the purpose being to remove all surplus growth of the limbs while very small.

Project 4: To compare clean culture and sod in a cherry orchard, to determine whether it is practicable to grow cherry trees in sod provided they are properly fertilized. On this plat nitrogenous fertilizers were applied to some of the trees in the spring and have already shown excellent results in foliage and in growth produced.

Project 5. This cover crop experiment was started a year ago on a block of spy trees planted the previous spring. The object of this experiment is to test the relative values of the different kinds of cover crops now most commonly used, ascertaining the total amount of organic matter being added by each of the different kinds and their relative effects on growth and fruit production.

In addition to these plots a block of Bartlett and Seckle pears and a block of Abundance plums were planted for further experimental work. A young peach orchard was set this spring to test the nitrogen requirements of peach trees, and the differences in the effect of nitrogen applied at different times. Five acres of Concord grapes were set early this spring for further work on fertilization and pruning grapes and also about an acre of Washington asparagus, a rust resistent strain developed by the Government which we hope to disseminate to the growers throughout the State interested in this crop. We are also carrying on a variety test of strawberries and have made some smaller plantings of loganberries, dewberries and other bush fruits, testing the varieties and making fundational plantings for future plant breeding work of bush fruits. Detailed outlines of these experimental projects already developed have been submitted to you.

Early in the spring we had the pleasure of an inspection trip through these grounds by the Experimental Committee of the Michigan State Horticultural Society. We hope that this is going to prove an annual event that we may be in closer touch with the economic needs of the fruit growers and receive such suggestions in the developing of these projects as they have to offer.

The credit for the excellent development of these grounds the past year is due largely to the capable and conscientious work of Mr. H. D. Hootman, superintendent of the grounds.

Respectfully submitted,
C. P. HALLIGAN,
Horticulturist.

East Lansing, Michigan, June 30, 1921.

SOUTH HAVEN STATION REPORT.

To Director R. S. Shaw:

Dear Sir:

A few years ago this Station entered into a cooperative contract with the Office of Pomology of the United States Department of Agriculture for the use of the South Haven Experiment Station for fruit tree breeding work.

The problem of developing blight resistant pears and of a peach hardier in bud than any we have at present, were the primary projects to be considered. In addition to this the breeding of other tree fruits such as apples was also undertaken. During the first two years on this contract Mr. Wight of the federal office spent much of his time at the Station making crosses and growing the resultant seedlings. This work has now developed to such an extent

that our present acreage is insufficient for testing out all of these young trees.

A recent visit of Mr. L. C. Corbett and Mr. L. B. Scott of the Office of Pomology, at Washington, to inspect the work that has been done and the material at hand, impressed them so favorably that they are very anxious to have the work extended and desire to help financially in such an extension of this work as is possible.

There is a very pressing demand at the present time for work upon some of the problems in the growing of small fruits for the southwestern section of the State. Local growers around South Haven are very anxious for us to undertake this work and we have reason to believe that the fruit growers in the vicinity of this Station would be glad to furnish the land free of charge for this work. A recent inspection trip by the writer in company with Mr. L. B. Scott, special investigator in nursery stock propagation, impressed him with the adaptability of the climatic and soil conditions in the vicinity of South Haven for the production of fruit tree stocks. Inasmuch as we already have a station there he is anxious to obtain an acreage for this work in this vicinity, carrying on the work cooperatively as we have previously been doing with the fruit breeding work. It is the hope of the writer that such a cooperative contract may be entered into by this station to develop this work.

At present there exists at the station grounds one of the largest and best collections of species of peach trees that can be found in this country as a foundation for future breeding work; also one of the best collections of pears, including some very desirable fire-blight resistant stock from China which the government collected a few years ago and has since ascertained its value as blight resistant stock.

During the past year we have been successful in inducing the city officials to take care of the drainage that formerly flowed on to a section of this property, keeping a large area in a very wet and unsuitable condition for the growing of fruit trees. Trees upon this block since the drainage matter has been controlled have been making an excellent new growth.

Mr. Stanley Johnston, superintendent of the station grounds, has been giving much of his time to other experimental work being carried on by this office throughout the fruit belt, especially along the lines of spraying and dusting, by assisting Mr. Dutton. During the winter months he took charge of the short course teaching work in horticulture. It is a pleasure to express our appreciation of the services Mr. Johnston has rendered the past year.

Respectfully submitted,
C. P. HALLIGAN,
Horticulturist.

East Lansing, Michigan, June 30, 1921.

REPORT OF THE SOILS SECTION.

Director R. S. Shaw:

The different lines of experimental work undertaken by the members of the Soils section have been conducted with enthusiasm, and gratifying results have been obtained.

The number of soil fertility projects on mineral soils has been increased until there are underway forty-five in rather widely separated areas of the State. The request for cooperative tests and demonstrations has been greater than we could put on and care for properly. A notable example of the success of this movement is the interest manifested in Kalamazoo county. Here the board of supervisors set aside sufficient funds to conduct tests on different soil types. County Agent R. L. Olds deserves much credit for the success of this campaign. The results that have been obtained have been reported in the Experiment Station Quarterly, bulletins, and the agricultural press.

Several muck land cooperative fields are in progress. Cultural operations and different combinations of manure and fertilizers are showing striking results on some of the deposits that have been under cultivation a number of years. Thus far the work has been well received and as with the mineral soils the requests for cooperation by farmers have been greater than could be met. As a result we are attempting to so distribute these that the maximum number of farmers will be served. In this field the cooperation of county agents has been of great value in many respects.

The researches of Dr. G. J. Bouyoucos on the soil solution, soil moisture and the causes of the appearance of frost on the muck areas have been conducted with vigor, care and foresight.

Mr. Spurway has continued the investigation on the effects of fertilizer salts on soils. Such information is fundamental to a knowledge of the proper use of such materials. Mr. Millar in addition to his instructional duties has obtained information on the soluble materials in cropped and virgin soils.

The soil survey is progressing satisfactorily. Field parties are at work in St. Joseph, Ottawa and Ontonagon counties. The employment of a leader of field parties should enable the work to be correlated and maintained at a high standard.

The various members of the Soils section desire to express their appreciation of your timely advice and support during the year.

Respectfully submitted,

M. M. McCOOL.

East Lansing, Michigan, June 30 1921.

REPORT OF UPPER PENINSULA EXPERIMENT STATION.

Director R. S. Shaw:
East Lansing, Michigan.

Dear Mr. Shaw:

I herewith submit a brief report of the work of the Upper Peninsula Experiment Station for the fiscal year ending June 30, 1921. The work that has previously been carried on, has been continued, and considerable expansion has been made along several lines, especially so in the crops experimental work conducted by Mr. G. W. Putnam, and the plant disease work in charge of Mr. J. E. Kotila, whose reports are hereto appended.

More fencing has been done, and considerable more land put under cultivation. It is the plan now to make land clearing a major project for the balance of the season in order to enable us to produce sufficient feed to increase our herds and flocks.

The past season has been very favorable for a large crop production. Our Wolverine oats averaged over 100 bushels per acre, and the sunflower field produced 24.6 tons per acre, weighed just before putting into the silo. The sunflower crop is very rapidly finding its place as a standard silage crop on stock farms of the Upper Peninsula, where it is replacing corn, peas and oats. Its high yielding power, resistance to frost, combined with comparatively high feeding value, is doing much to popularize it where corn is not successfully grown.

The flocks of sheep have been steadily growing and improving, by the use of good sires and good pastures. The flock now consists of 271 matured sheep of the Hampshire, Shropshire and Rambouillet breeds and the different crosses of these breeds. Careful records are kept of each individual in the flock as to weights of fleece, breeding, and weights of lambs. The object is to determine what breed or cross will be best adapted for Upper Peninsula conditions, and to enable us to eliminate poor individuals from the flocks. Ram lambs and ewes were sold to the farmers for breeding purposes and all surplus stock sold to Clay, Robinson & Co. At the close of the lambing season, the Station had 120% of living lambs.

The dairy herd now consists of thirteen milk cows, three heifers, one herd bull and eleven young stock. Seven bulls, three heifers and three cows were sold for breeding purposes. The best individuals have been kept in the herd which enables us to steadily increase the quality and production. The average production during the past year was 13,000 pounds of milk. The majority of the milk and cream has been sold to the milk and cream trade in Marquette and Munising.

Two teams of horses were sold last fall to lumbermen, and one team purchased this spring. The Station now has five horses.

A flock of Barred Rock chickens has been kept. The cockerels were sold to the farmers for breeding purposes and the eggs for hatching.

Considerable improvement has been made with roads around the buildings. A new road has been graded and graveled from the office to the main road and another from the horse barn to the main road.

The house on the forty acres purchased last year, has been completely remodeled inside, a new kitchen built and a new basement constructed.

The laboratory room has been built in the grain room above the office, and partially equipped.

The boarding house has been painted on the outside and kalsomined on the inside. The office building has also been painted.

Some new machinery has been purchased for the farm, and for experimental work.

The annual round-up put on August 10–11, was quite successful, and approximately 3,000 people were in attendance. Demonstration work along live stock and farm crops lines was a feature, and a speaking program was rendered in the afternoon. Alger county generously donated an excellent barbecue dinner in order to assist in accomodating the crowds. The boys' and girls' club members' camp was put on at the time of the round-up. They received special instructions in live stock and crop lines, and live stock prizes were given to the winners of the final judging contests.

Respectfully submitted,

D. L. McMILLAN,

Superintendent.

Chatham, Michigan, June 30, 1921.

Mr. D. L. McMillan, Superintendent,
Chatham, Michigan.

Dear Mr. McMillan:

I herewith make report of plant disease investigations carried on at the Upper Peninsula station during the fiscal year ending June 30, 1921.

POTATO DISEASES.

These investigations have been a continuation of the projects started in 1919, supplemented by the potato leaf-hopper investigations which were started in 1920. The 1919 and 1920 seed treatment experiments having shown that neither formaldehyde nor corrosive sublimate, which are usually recommended for the control of seed-borne diseases such as scab, black scourf and black leg, were effective in the control of scab under conditions existing at this Station. The 1921 seed treatment experiments were supplemented by soil treatment experiments for scab control. In these experiments, sulphur in various forms was applied to the soil as a top dressing before planting the tubers. The importance of scab control in the limestone areas of the Upper Peninsula becomes significant when it is learned that even the first crop of potatoes grown on a given piece of land, bears a high percentage of scab, and succeeding crops on the same ground, even if grown after an interim of 10 years, are largely unmarketable because of this disease.

Hill selection work for studying the dissemination of Mosaic, Leaf Roll and Streak from diseased to healthy hills has been continued and also the cage experiments to determine whether insects are factors in spreading these diseases.

Spraying experiments for control of hopperburn (tipburn) and leaf diseases which were started in 1920, have been supplemented by the use of dusts in 1921.

Most of the laboratory researches have been devoted to the investigation of the Black Leg disease of potatoes which is very prevalent in the Upper Peninsula potato fields.

OTHER DISEASE.

Whereas most of the time has been spent in the investigation of the potato diseases of the Upper Peninsula, a little time has been devoted to making observations on the diseases affecting the other crops grown at the Station, more particularly black stem rust of wheat and rust of sunflowers.

Owing to the increased importance of the latter, as a silage crop in the Upper Peninsula, the control of sunflower rust has become urgent and to this end preliminary seed treatment experiments were undertaken in 1921.

With an expression of appreciation for the hearty cooperation you have given to the disease work carried on at this Station, I am

Respectfully,
J. E. KOTALA,
Research Assistant in Plant Pathology.

Chatham, Michigan, June 30, 1921.

Superintendent D. L. McMillan,
Chatham, Michigan.

Dear Sir:

I herewith submit a brief report of the experimental crops work for the year ending June 30, 1921.

The data obtained from the grain plots of 1920 would indicate that spring barley, oats and field peas can be grown very successfully; while spring wheat, winter wheat, soy beans and corn can be grown successfully only when the season is especially favorable, or, in the case of soy beans, and corn, when seeded well to the southern boundary of the territory. Black Stem Rust is the principal cause of failure of the wheat crop, as well as soy beans and corn. This disease is prevalent throughout the territory, causing the growing of wheat to be classed as an uncertain crop.

Experiments with forage crops would indicate that mixtures of oats and vetch, or peas and oats, is a very dependable short season hay crop. Sunflower experiments would indicate the most successful method of growing the crop for silage, is to seed early, in rows from 30 to 36 inches apart, at from 6 to 8 pounds of seed per acre.

Potato experiments in progress, indicate the necessity of careful selection work to secure disease free seed, stock of high yielding power. Green Mountains and Rurals are the outstanding varieties in variety test plots.

Cooperative work in studying and classifying pea varieties, is in progress with the East Lansing Station. One hundred and fifty-four strains are being tested this year. Commercial pea varieties are being tested for grain and forage production. A strain of English field peas is being increased for distribution, also a strain of Alaska canning peas.

Cooperative crop testing in various counties has been increased with the addition of Mr. John Hammes as field man. Twenty-three demonstrations have been placed in twelve counties of the Upper Peninsula.

Respectfully submitted,
G. W. PUTNAM,
Research Assistant in Farm Crops.

Chatham, Michigan, June 30, 1921.

REPORT OF THE DIVISION OF EXTENSION WORK.

President F. S. Kedzie.

Dear Sir:

The work of the Extension division is given as a brief summary of the results accomplished under the various projects which have been established under the terms of the Smith-Lever act. Under the terms of this act, all work undertaken must be approved by the Secretary of Agriculture before it is begun. This is accomplished by means of written projects outlining the purposes and methods of procedure of each branch of work. For each subsequent year a detailed annual plan of work is required to be submitted to the federal office for approval. The projects in effect during the year are as follows:

1. Administration.
2. County agents.
3. Home economics.
4. Home demonstration agents.
5. Boys' and girls' clubs.
6. Farm crops.
7. Live stock.
8. Horticulture.
9. Potatoes and vegetables.
10. Soils.
11. Farm management demonstrations.
12. Insect control.
13. Household engineering and drainage.
14. Markets.
15. Poultry.

County Agricultural Agents:

During the year 65 counties have had county agricultural agents. This is the largest number of agents since the war, at which time emergency funds extended this work into 68 counties. The counties which have been added this year are: Crawford, Gratiot, Hillsdale, Huron, Leelanau and Oceana. There are sixteen counties having no agents, five or six of which probably would not be able to finance the work alone.

The development of the county farm bureaus during the year has stimulated and strengthened the work, not only by providing funds for the employment of agents, but also by bringing larger numbers of farmers into active, sympathetic contact with the county work. The farm bureau serves as a means of making the farmers themselves an active partner in developing a plan of work for their county and assisting in carrying it out. The work undertaken in the individual counties varies greatly according to the regional interests. All programs of work are built around the important sources of income and include home and community interests. Success in carrying out such an inclusive and often complex program is dependent upon finding men or women who are willing and able to assist locally. These helpers must be found and developed until they become recognized leaders among their associates.

Financial support is from two sources: farm bureau memberships and appropriations made by boards of supervisors. Membership fees used for

county agent work this year amount to $89,000. Appropriations by boards of supervisors aggregated $174,906, as compared to $129,948 the previous year. In addition to these amounts, State and federal funds provide for $1,200 per county, which is paid directly to the county agent by the College. More adequate funds have made it possible to pay better salaries to agents, resulting in fewer changes in the staff and the attracting of more experienced men to the work.

The problems of organization during the year have been exceedingly complex. The desire on the part of the farmers for strong, economic institutions through which they could combine their efforts for marketing purposes was greatly stimulated by the organization of the farm bureaus. Inasmuch as marketing was the fundamental purpose of these organizations, the efforts of the county agents along these lines were directed by the marketing specialists of the College, and the summary of these results is given under that heading. In all organization work, however, the County Agricultural Agent is the active leader in his county with a constant first-hand, personal knowledge of local situations in each marketing center. When cooperative institutions are in need of help during their formation or later, the agent brings to them the best available information regarding required volume of business, equipment, constitutions, by-laws, financing, contracts, affiliations with commodity exchanges, etc., and gives the membership a full acquaintance with the local and state-wide situation regarding cooperative concerns. During the year material assistance was given in the formation of 321 such organizations.

The cooperative marketing associations are proving to be a strong factor not only in marketing but also in promoting production projects. Through these institutions large groups of members can be reached in supplying better seeds, in standardizing produce, in promoting better live stock, and in fact, in carrying out any economic, educational effort.

The county agent cooperates with all forms of organizations which can, be used to effect his purpose. These include granges, gleaners, farmers clubs and farm bureau locals. The agents report that their work has extended into 928 communities, and of this number 871 have some form of local organization, with committees assisting in carrying out a program of work.

Soils:

Reports for the last calendar year from 48 counties indicate that there were 15,802 farmers who used fertilizers, either in demonstrational work or through the assistance of the agents. Forty-one counties show that lime was used on 3,609 farms totaling 198,574 tons; soil was tested for acidity on 988 farms; 27 agents report that 27,060 acres of clover or other legumes were plowed under for green manure; in 22 counties there were 51 drainage systems planned and adopted on an area of 5,855 acres.

It should be remembered that high freight rates and decreasing prices of farm products has kept many farmers from undertaking anything of this kind.

Crops:

The work done by the agents with grain and forage crops has been in close cooperation with the Farm Crops department and the Seed Department of the Farm Bureau. Through this cooperation a general plan for the State and counties is made and carried out, based on variety tests and demonstrations well distributed over the grain area. All demonstrations are located in places where they can be readily observed by other farmers.

Observation tours are planned for the purpose of bringing large numbers of farmers to these demonstrations at times in the season when results are most striking.

Alfalfa growing has been promoted with greater success probably because of the fact that great quantities of guaranteed hardy variety seed was made available through the Farm Bureau. About 153,000 pounds of Grimm and 215,000 pounds of common alfalfa of guaranteed origin was sold to the farmers through the Farm Bureau during the season. Reports from 38 counties show that sweet clover was introduced or culture methods modified on 902 farms involving 7,466 acres. Hubam clover is being introduced this year and 28 counties are cooperating with the College in its culture. A strong impetus to the production of higher quality of red clover seed has been general this year by the use of seed of guaranteed origin. In 33 counties soy bean demonstrations were carried out on 285 farms on a total of 1,448 acres. Legume cultures supplied by the Department of Bacteriology at cost through the county agents amounted to approximately 7,000 bottles during the season.

Statistics from the agents showed that 3,340 farms were influenced to use improved seed oats and 668 farms offered such seed for sale. Twenty-two counties reported barley variety tests and demonstrations. Under the supervision of the Farm Crops department, thirteen counties are conducting ear-to-ear corn demonstrations. Statistics from 28 counties show 49,832 farms as planting selected seed corn.

Rosen rye has become the standard variety of the State. To assure a permanent source of unmixed seed the agents are now cooperating in the distribution of seed raised from head-selected stock. Thirty-five counties reported last season that there were 2,727 farms on which cultural methods relative to wheat were modified involving 44,870 acres. Seed-wheat was treated for smut on 3,275 farms.

Statistics from 42 counties last season showed that 3,732 farmers treated seed potatoes for disease control involving 13,720 acres; that 1,902 farmers sprayed potatoes on a total of 10,073 acres; that cultural methods were changed on 1,658 other farms including 7,332 acres.

Potato seed inspection was carried out in 16 counties. This season 24 counties are starting this work. Last year 269 acres were inspected as compared with 1,100 being offered for inspection this year.

During the season agents gave assistance with the planting of 411 orchards. Spraying was done on 3,416 farms and pruning on 6,194 farms.

Insect control:

Efforts in insect control included work with Hessian fly, army worms, chinch bugs, grape leaf hopper, berry moth, rose chafer, codling moth and leaf hopper and grasshoppers. Grasshopper control work was carried on in 16 counties with the financial support of boards of supervisors. The organization for carrying on this work in each county is in the hands of the county agent. Estimates from two counties give amounts saved by grasshopper poisoning as $200,000 and $750,000. Reports show that there were 10,779 farms on which insect control methods were followed involving 587,122 acres and that 3,651,603 pounds of poisoned bait were used.

Live stock:

The live stock projects include standardization of breeds by communities and counties, the elimination of scrub sires and the introduction of pure bred bulls and high grade females, the erection of silos, the improvement of feeding and care, the control or eradication of disease, and organization work such as

assistance given in the formation of cow testing, live stock shipping and breeders' associations.

The statistical statement of this work as given in the calendar year reports by the agents, is as follows: Registered stallions and mares secured, 78; dairy bulls, 202 and beef, 69; registered cows, dairy, 222 and beef, 41; high grade cows, dairy, 352 and beef, 100; registered rams, 97; registered boars, 61; cows tested for milk production through associations or by individuals, 6,790; cows discarded as result of test, 377; farmers assisted in figuring balanced rations, 1,044; silos erected, 784; farms on which poultry practice was modified, 2,240; animals tested for tuberculosis, 5,265; hogs vaccinated for cholera, 4,314; hogs treated for hemorrhagic septicemia, 171; farmers assisted in controlling necro-bacillosis, 101, farmers assisted in controlling contagious abortion, 54; farms on which beekeeping was introduced or the handling of bees modified, 206; involving 1,975 hives.

The live stock organization work statistically stated is as follows: associations organized previous to 1920 numbered 84 with 3,330 members; in 1920, 29 associations were organized with a membership of 619. Since December 1, 1920, there have been formed 25 live stock organization, referred to under the section on organization.

Tuberculosis:

The boards of supervisors in ten counties have made appropiation for furthering the work, the amounts varying from $1,000 to $5,000, and twenty counties report either considerable testing done or preparations being made for undertaking this project. The live stock men are taking a keen interest in it and the campaign for control of the disease is spreading rapidly over the State. The counties in which appropriations have been made are: Livingston, Emmet, Charlevoix, Antrim, Grand Traverse, Jackson, Hillsdale, Gogebic, Leelanau and Wayne.

Farm management.

In 33 counties the agents cooperated in the holding of farm accounting schools. Fifty-six county agents distributed a total of 950 account books. Two hundred and fifty-three farmers were assisted in summarizing and interpreting their accounts and 122 made changes in their business as a result of keeping accounts; 1,158 farmers adopted cropping, live stock, or complete farming systems according to recommendations; 158 buildings other than homes were constructed or remodeled according to plans furnished; 18 farm leases were drawn or modified.

Labor.

The reports show that the agents assisted the farmers in getting 1,352 farm laborers and that 146 farmers were assisted in securing machinery to economize labor.

Credit.

Requests by the farmers for assistance in obtaining better credit facilities have been many and the farm loan association has been an important factor in meeting the credit needs since provisions were made for such associations. The agents assisted in the formation of 11 farm loan associations, and five other credit associations, involving 707 farmers.

Marketing.

For the calendar year 1920, the reports of 60 county agents show that there were 236 marketing associations formed, with a membership of approxi-

mately 30,000. The business transacted by these new associations, several of which had been organized but a short time when these figures were obtained, amounted to about five million dollars, with an estimated saving of three hundred thousand dollars. Including all types of buying and selling associations with which the county agents work, there was a total of 481, November 30, with a membership of about 60,000 and transacting business amounting to about $14,500,000 with a saving of $1,400,000. Since December 1, 1920, there have been 77 cooperative marketing associations formed.

In the counties having agents there has been reported a total of 670 local organizations performing marketing functions.

Meetings.

The many meetings held in every county each year are primarily for the purpose of planning the county and community programs, devising methods for carrying them on, following up the work and explaining the results achieved. These meetings during the winter consist largely of schools and institutes and of other meetings for organization and for discussing and planning the work; during the summer, meetings are held at demonstrations, observation tours are conducted and other meetings for organization and follow-up, both community and county-wide, are held. Much assistance is given by the extension specialists in conducting these meetings. The following is a classified list of the meetings held:

	Number	Attendance.
Annual Farm Bureau meetings	63	6,029
Executive committee meetings	461	3,363
Community meetings	1,856	90,929
Community committee meetings	442	2,706
County project committee meetings	137	2,755
Farm Bureau picnics	50	89,915
Observation tours	57	2,505
Other Farm Bureau organization meetings	706	42,197

In 21 counties there were 95 extension schools held with a total attendance of 13,141; in 28 counties 1,256 farmers' institutes were held with an attendance of 12,599. The total number of the different kinds of meetings held was 8,682 with an attendance of 347,353.

STATISTICAL SUMMARY.

From July 1, 1920 to June 30, 1921.

	July.	August.	September.	October.	November.	December.	Totals.
Number of agents reporting	57	54	54	55	52	56	....
OFFICE.							
Days in office	513½	580½	484½	561½	763	626	3,529
Calls on agent:							
Personal	5,029	5,805	5,203	5,322	4,752	4,708	30,819
Telephone	5,586	6,425	5,704	5,694	5,997	5,415	34,821
Letters written	6,807	8,421	6,053	6,323	6,238	6,168	40,010
Circular letters mailed	56,643	83,327	53,621	38,207	58,235	53,940	343,973
Articles published in local press	389	408	192	232	179	183	1,583
Bulletins distributed	6,498	8,490	13,003	11,950	7,033	11,663	58,637
FIELD.							
Days in field	754	870½	721	660	613½	532½	4,151½
Farm visits made	2,157	1,899	1,341	1,408	924	656	8,385
Demonstrations:							
a. Started	70	50	35	7	15	6	183
b. Visited	131	142	60	105	55	....	493
c. Meetings held at	44	112	59	33	34	6	288
d. Attendance at meetings	1,026	2,813	891	372	374	134	5,610
Other meetings held	381	359	247	295	386	278	1,946
Attendance	22,013	41,341	12,687	14,294	13,926	14,324	118,595

	January.	February.	March.	April.	May.	June.	Totals.
Number of agents reporting	59	60	60	60	61	60	....
OFFICE.							
Days in office	912	800½	779	665½	681	499½	4,337½
Calls on agent:							
Personal	8,114	8,053	7,780	8,986	8,889	6,720	48,542
Telephone	7,425	6,578	7,891	7,815	7,848	4,673	42,230
Letters written	8,044	7,917	8,868	8,960	18,120	10,932	62,841
Circular letters mailed	72,244	50,790	60,776	45,579	59,150	27,997	316,536
Articles published in local press	506	328	443	473	402	204	2,356
Bulletins distributed	16,344	5,649	6,980	8,030	15,985	12,551	65,539
FIELD.							
Days in field	789	580	623	760	1,057	846	4,655
Farm visits made	352	386	520	1,569	3,110	2,678	8,615
Demonstrations:							
a. Started	10	14	72	197	215	81	589
b. Visited	1	....	7	51	94	233	386
c. Meetings held at	6	19	46	42	48	112	273
d. Attendance at meetings	152	309	634	459	1,304	3,900	6,758
Other meetings held	526	583	401	418	367	278	2,573
Attendance	30,821	37,715	20,089	16,630	16,077	15,724	137,056

HOME DEMONSTRATION AGENT WORK.

During the year 11 counties cooperated with the College in the employment of home demonstration agents. This is a larger number than had previously been employed on regular funds. During the war while the total salary was paid from emergency funds, a larger number of agents were at work.

Each home demonstration agent is a permanent resident of her county and gives all her time to service among the women of the county. Her work includes demonstrations and personal assistance regarding nutrition, clothing, household management, interior decoration, poultry, girls' garment and canning clubs, and home accounts. Her whole work while dealing with these details is aimed at the broader purpose of stronger people, better homes and better communities.

Foods.

Food work has not followed the old line of cooking lessons and distribution of recipes. Instead of this the latest information on nutrition and diet has been given through food study classes, school feeding demonstrations and milk campaigns. This instruction has included selection, preparation and care of foods, planning of meals, and diet for children, and to meet special needs. This work is being given strong support by many public agencies such as Red Cross, churches, newspapers, libraries, women's clubs, granges and by the general public.

Three rural milk campaigns were carried on. During these campaigns the specialist gave 65 lectures to a total of 4,293 people. A very decided increase in the consumption of milk followed these campaigns, one dealer in a small town reporting an increase of 34% in his sales; another reported sales increased from 50 quarts daily to 70 quarts daily, and this in a community where there was much unemployment. Because of the greater use of milk, children have gained in weight, have acquired more life or energy, and have gained higher marks in their studies according to reports from teachers. Adults as well as children have also been physically benefited by the use of milk in the diet.

Besides the talks given in milk campaigns the specialist gave 47 food talks reaching 3,191 people. Much time was also given to assisting the traveling clinic of the State Board of Health at which time assistance was given to mothers in planning diets for special cases. These included principally diets for underweight and tuberculosis.

Nutrition clinics have been conducted by several of the home demonstration agents with malnourished children. There is a growing demand for this work. The mothers of under-nourished children are asking for the home demonstration agents and specialist aid, and several home demonstrations have been established.

Clothing.

During the year the extension clothing specialist has worked directly with the agents in the preparation of subject matter and illustrative materials. The dress form has been featured by popular demand. Demonstrations in dress form making have been given to organized groups and much effort has been given to the organization of the group to make it permanent as a means of promoting other lines of work. It is estimated that 2,500 of these forms have been made since December 1, 1920. This work is not only important, as a dress making aid but because it emphasizes the health side of clothing work and calls attention to proper posture and correct fitting of corsets and

shoes. Since December 1st, 111 dress form demonstrations have been supervised by the clothing specialist. At these meetings 465 women were trained to make the forms and are now teaching others. In each county having an agent approximately 200 forms have been made, making a total of 2,500. The forms are worth at least $10.00 each.

Millinery is being given more attention. One class has saved the women of one community $105.78. One afternoon's work by the specialist from the College and the agent saved the women $47.50 besides the fact that they were trained to do these same things in the future. Eleven millinery clinics have been conducted with a total attendance of 238, each attendant renewing at least one hat with increased value of from three to five dollars.

Household Management.

The service offered in household management aims to make house work in Michigan farm homes easier and more efficient. This is done through better planning of the work, better arranged kitchens equipped with modern devices. Service is also given in home accounting with the intention of developing a better planned expenditure of income in the interests of the life of the family. During the winter months ten kitchens were rearranged and equipped. A large number of home-made fireless cookers have been made under the supervision of the specialist and agents. Approximately sixty pressure cookers have been purchased as a means of saving time in cooking and canning.

At the present time groups of women in 21 counties are keeping accounts and a record of the family living coming from the farm. Visits are made to each group every three months to discuss further problems of accounting and budgeting.

Home convenience campaigns are conducted in the various counties culminating in a home convenience tour when the new things are inspected by those interested. Lectures and illustrative material are used liberally throughout the State, and results from this effort are never available in definite figures.

BOYS' AND GIRLS' CLUBS.

In club work emphasis has been placed upon the organization of local boys' and girls' clubs, each with a local leader through which the agricultural, educational and social program of the Extension Service might be carried on. The policy of cooperating with the counties in the employment of full time county club leaders has been extended into eleven counties. In 24 other counties paid club leaders for periods less than 12 months have been employed. In addition to these paid leaders there were 1,127 local volunteer club leaders.

Cooperation in the promotion of this work has been very generous from a large number of sources. Among these might be mentioned The Michigan Crop Improvement Association, The State Bankers' Association, The Michigan Potato Growers' Exchange, The Michigan Bean Jobbers Association, the Michigan State Fair, The West Michigan State Fair, Boards of Supervisors, Womens' Clubs, Farm Bureaus, Boards of Education, Development Bureaus, Teachers' Associations, together with a large number of commercial concerns.

State and county training schools have been held for the purpose of developing club leaders. Four state-wide training schools have been conducted in Grand Rapids, Kalamazoo and East Lansing. Twelve county schools were held. Through an arrangement with the Department of Public Instruction, a course in Club Leadership was presented in 19 of the County Normal Training Classes. Two hundred forty-six prospective club leaders received training in club leadership in this way. Clubs have been organized in fifteen

projects. The names and yearly record of work in these projects are given in the following table:

SUMMARY OF PROJECT RESULTS.

Club demonstration projects.	Organized clubs.	Groups finishing as standard club.	Enroll-ment.	Members reporting.	Value of products.
Corn	21	19	167	147	$3,264 25
Potato	31	30	247	201	14,543 00
Garden	329	255	14,113	6,108	80,566 63
Pig, breeding	62	60	438	393	11,511 63
Pig, sow and litter	21	21	181	131	13,747 50
Dairy heifer	22	20	272	209	31,437 21
Sheep	7	7	63	59	4,683 00
Poultry	26	19	258	136	6,522 30
Canning	177	160	1,964	1,625	34,531 40
Cooking	8	8	88	39	280 79
Hot lunch	78	70	1,807	1,235	3,391 93
Clothing	263	245	1,857	1,148	10,924 52
Handicraft	69	60	718	482	2,843 04
Bean	6	6	32	29	1,363 00
Rabbit	7	4	55	18	704 09
Totals	1,127	984	22,260	11,960	$216,922 35

The Third Annual Boys' and Girls' Club Week was held at the College. Only those Club members who had won state or county championships in their various projects were eligible to attend. One hundred thirty-three club champions, together with their leaders, representing 26 counties, were in attendance during the week. The First Annual Club Week for Northern Peninsula club members was held at the Experiment Station, Chatham, in August. One hundred winners of state and county championships attended this club camp.

Scholarships.

In accordance with action taken by the State Board of Agriculture, scholarships at Michigan Agricultural College were awarded to winners of state club championships. Several of these winners are now students at Michigan Agricultural College. Scholarships to the 16 weeks' short course were awarded to the all around club champion in each county in which organized boys' and girls' club work was done. Several of these winners enrolled for the short courses during the winter.

FARM CROPS.

The best established extension projects in Farm Crops are based on the introduction in a large way of improved crops varieties developed at the Michigan Experiment Station. Efficient introduction is accomplished through the Michigan Crop Improvement Association, an organization of farmers who are interested in growing improved high yielding varieties. These growers are provided with pure seed from the Experiment Station increase fields, which is grown under a system of careful field and bin inspection, for sale under certification. The Michigan Crop Improvement Association is closely associated with the Farm Bureau seed department.

This organized varietal distribution project has proven of great effectiveness. Ninety per cent of the rye in the State of Michigan is Rosen, first distributed from the Experiment Station in 1912, or near Rosen, and for the first time Michigan ranks first as a rye state. In six years' work the Robust bean

has become the leading white pea bean variety. Wolverine, Worthy and College Success oats are the best known varieties in the State. Nearly all of the Smooth Awn barley is sold annually for seed. These varieties are all association varieties secured from the Michigan Experiment Station. This developed machinery is proving ideal for the quick increase on safe grounds of the Hubam clover.

Assistance has been given to the county agents in working out definite crops for each county. During the past year special attention has been given to exhibits both in the State and at the International Grain and Hay Show. Thirty-two counties have asked for special exhibits in addition to the two State Fairs.

The variety demonstrations held at many points throughout Michigan, pave the way for the safe introduction of high yielding varieties or new crops. These demonstrations not only add greatly to information regarding crops, but are used repeatedly by county agents as field demonstrations and are the object of numerous field trips.

The Michigan Crop Improvement Association continues to be a very active arm of the Farm Crops Extension Service in Michigan in raising the seed standards and furnishing a supply of seeds of superior and adaptable varieties. Through the cooperation of the Farm Crops department, State Farm Bureau, county agents and cooperative elevator managers, the Association is serving nearly every section of the State, and in addition to Michigan farmers it is in direct contact with many farmers of New York, Pennsylvania, Indiana, Illinois, Nebraska, Minnesota, Wisconsin, Alberta, etc.

The membership of the Association is somewhat larger than last year with a total of 712 registered seed farms which are located throughout the agricultural sections of the State.

The efficiency of these seed farms and the quality of their product was clearly demonstrated at the 1920 International Grain and Hay Show held at Chicago. In competition with the United States and Canada, members of the Michigan Crop Improvement Association won the first twenty-eight prizes offered in the rye class and fourteen of the first twenty prizes in the soft winter wheat class. In addition to these several prizes were won in oats, soy-beans, barley, etc.

In February the Farm Crops department of the Michigan Agricultural College distributed 1,598 pounds of the Hubam Clover (Annual White Sweet Clover) to 580 members of the Association to be grown for seed purposes under the supervision of the department, and in accordance with the regulations of the Association. At the present time there are 1,200 acres of the crop growing in Michigan which will furnish seed, the origin, purity and quality of which are known and will be certified and guaranteed.

The widespread use of Rosen Rye of high purity has played a fundamental part in advancing Michigan from the fourth place to the first place in the rye production of the United States. Improvement is being made with Rosen seed by the adoption of the head selection practice. This year eight growers followed this system with the result that there are now 1,700 bushels of seed available for planting this fall which in accordance with the past results should yield five to ten bushels more per acre than even the best of registered Rosen. It is thought that this seed placed on Michigan's half million acres annually devoted to rye, will produce an increase in production of two million bushels.

In 1920 nearly ten thousand pounds of alfalfa seed were placed in farmers' hands throughout the State for demonstrational purposes. The results

were so striking that in the spring of 1921 some 100,000 pounds of pure northern grown Grimm Alfalfa seed were sold to Michigan farmers through the State Farm Bureau seed department. It is believed that the alfalfa seed demonstrations have accomplished a great deal for Michigan agriculture in that they have brought about the success of thousands of acres of excellent alfalfa stands, the value of which is inestimable.

The soy-bean demonstrations have added much impetus to the soy-bean production this year, especially to the growing of the superior varieties and to the producing of pure seed of the same.

Farmers in general are anticipating the planting of an exceptionally large acreage of soy-beans next year due to the failure of their clover seedings this year. In that Michigan is now producing a large acreage of pure seed of the best adapted varieties, it is thought that the extension service rendered with soy-beans will prove to be of considerable value to our farmers next spring.

This year the Farm Bureau seed department found that a great per cent of clover seed produced in Michigan is not of the desired high quality, consequently every effort is being made to raise the standards of the growers by encouraging the eradication of weeds, preparation of good seed-beds, and the use of lime and acid phosphate.

It is impossible to measure the extent of interest in much of the field work, as these demonstrations are teachers whose lessons are constantly being spread in the conversations of the many interested persons who visit them.

In order to more fully emphasize the lessons which the various demonstrations teach, special farm crops tours are being planned in cooperation with county agents. On these tours farmers will visit the various fields in groups while the extension specialist explains the purposes and results of the demonstration. One county tour has already been held and seven more are scheduled for the summer. Demonstrations emphasized are seed, forage, and green manuring uses of Hubam clover, variegated and common types of alfalfa, alfalfa cultural methods, sweet clover for hay and pasture, variety tests and demonstrations of pedigreed grains, demonstrations of corn improvement by the ear-to-row method, etc.

Considerable time has been spent in conference with county agents in planning yearly crops programs, and particularly in carrying the methods of experienced agents to those just beginning work.

Great emphasis has been laid upon education by means of crops exhibits. Large crops displays, educational in nature, and with one or two members of the Farm Crops department in attendance, were shown at the State Fair, Detroit, the Western Michigan Fair, Grand Rapids, the International Grain and Hay Show, Chicago, and Farmers' Week at M. A. C. It has been the aim to emphasize some important phase of crops work in these displays by high quality material, enlarged photographs and a few short but emphatic signs. Large detailed charts have been avoided as expensive and unattractive to the great majority of people who visit these fairs, and must of necessity receive their impressions hurriedly. In addition to the large displays, fourteen county fairs were served with smaller exhibits emphasizing the importance of pedigreed seed.

During the coming season large education displays will again be shown at Detroit, Grand Rapids, Chicago and M. A. C., and the work with county fairs will be greatly enlarged. Already plans for exhibits are under way to meet the needs of thirty-four county fairs which have requested them.

Last spring a start was made in corn improvement work throughout the State by the ear-to-row method. The difficulty has been to get improved

seed corn near enough at hand to meet the local climatic conditions. So the work of improvement is being carried to the community itself by improving the best corn to be found there by this method of selection. Thirteen of these ear-to-row demonstrations were planted this spring, ranging from Manistee county on the north to the southern boundary of the State. One demonstration on the time of seeding rye is being conducted in Emmet county.

To demonstrate the merit of pedigreed varieties of grain, tests have been conducted on farms located in various parts of the State. In these demonstrations locally grown varieties are always included with pedigreed strains and careful comparisons are made. Results have shown that in nearly every crop except corn one or more pedigreed varieties have out-yielded the local varieties. A continuation of these demonstrations will make it possible to safely recommend varieties adaptable to local conditions.

The first demonstrations of this kind were conducted in 1918, when five wheat tests were planted. This has since increased to include oats, barley, corn, field beans, soy-beans, alfalfa and millet.

Regional tests are particularly necessary for corn. It is planned to continue corn demonstrations until safe recommendations can be made for each belt of counties in the State.

Barley is grown largely from mixed seed. The barley demonstrations being conducted give a comparison of Michigan-2-row, Michigan Black Barbless, and Wisconsin Pedigreed with each other and with local seed.

Regional demonstrations are also conducted for wheat, alfalfa, soy-beans and short season hay crops. All demonstrations are used as centers for summer meetings and the results are used as material for winter schools.

COW TESTING ASSOCIATIONS.

The work of the Extension Specialist in Dairying during the past year has consisted chiefly of aiding in organizing and supervising cow testing associations, teaching in extension schools and attending general community and farm bureau meetings at which dairy problems and organizations were discussed. The work during the past year has been of a more comprehensive nature than in the past, not being confined to the so-called project work although interest in these phases of the work has been very good. Michigan farmers are successfully solving many of their problems through organization, and an attempt has been made to make the dairy extension work an aid to their program. The Boys' and Girls' Live Stock Club work has maintained a healthy growth and has served to make the dairy extension work of a broader nature and more effective in teaching the principles of dairying.

July 1, 1920, there were fourteen cooperative cow testing associations in Michigan with a membership of 367 farmers owning 4,093 cows.

Eleven cooperative cow testing associations were active in Michigan, July 1, 1920, and were as follows:

Kent County Cooperative Cow Testing Association.
West Allegan County Cooperative Cow Testing Association.
Emmet County Cooperative Cow Testing Association.
Van Buren, No. 1 Cooperative Cow Testing Association.
Wayne County, No. 1 Cooperative Cow Testing Association.
Van Buren, No. 2 Cooperative Cow Testing Association.
Wayne County, No. 2 Cooperative Cow Testing Association.
Lapeer County Cooperative Cow Testing Association.

Hillsdale County Cooperative Cow Testing Association.
Antrim County Cooperative Cow Testing Association.
Kalamazoo County Cooperative Cow Testing Association.

There were in these eleven associations, July 1, 1921, 235 members owning 2,785 cows.

The cow testing association work was affected quite materially by the serious decline in prices of dairy products during late winter and early spring. Eight of the associations operating last year have discontinued work. Five new associations have been organized and four of the old associations have maintained their organization and are planning to start again when conditions are better adjusted and the farmers feel more encouraged. Part of these will probably start this fall. The need for this work is greater now than during the past two years when almost any cow would pay. Standards of production must necessarily be raised under present conditions and dairymen are beginning to realize it, as is indicated by requests for information and help from communities desiring to organize.

SHEEP HUSBANDRY.

Extension work in sheep husbandry has been carried on during the past year cooperatively between the Bureau of Animal Industry of the United States Department of Agriculture and the Michigan Agricultural College.

The purpose and aim of this work has been to assist sheep men of the State in securing and disposing of suitable breeding stock, to teach interested parties the best methods of breeding, feeding, general management and care of the flock; to call to the attention of flock owners the value of pure bred rams; to collect data as to the cost of production; and to advise growers of the necessity of producing clean wool of good length and staple instead of so much discount wool of short staple.

The Extension Specialist has cooperated with the Wool Department of the Michigan State Farm Bureau in their efforts to secure for the sheep men of the State a satisfactory market for their wool. A number of the grading stations have been visited and the educational work in connection with the pooling and grading of wool has been kept at the front at all times.

The educational work has been taught through lectures and demonstrations, at various county meetings, extention schools, and farm visits, most of which were cooperative with the county agents.

Very little work has been done in connection with the Boys' and Girls' Sheep Clubs, but it is the hope of the department that considerable work can be done along these lines the coming year.

Flock owners are keeping record books for yearly sheep management and demonstration, and considerable valuable information will be obtained at the completion of this work. The object of this work is to draw a comparison between the methods commonly used in the community, with those which have been used successfully at colleges, experiment stations or elsewhere.

HORTICULTURE.

This project was without a leader during the first half of the fiscal year. During the winter meetings held in fruit sections it was made clear that one of the important questions on which gruit growers needed help was fertiliza-

tion of tree and small fruits covering the whole question of tree and small fruit cropping, sod mulching in connection with the use of commercial fertilizers, and the use of these forms of plant food to supplement the stable manures. Next in importance has been the problem of insect and disease control. But few demonstrations were given in spraying. Large numbers of pruning demonstrations were asked for in sections where little spraying was practiced, and spraying was far more important than pruning.

Fertilizer demonstrations have been carried on largely in Berrien and Van Buren counties, but some demonstrations have been put on in sixteen other counties.

POTATOES AND VEGETABLES.

The main purposes in view in promoting potato production are lower cost of production, better quality of seed and table stock, more stable market, greater net profit to growers and greater value per dollar for the consumer. The methods of attaining these results are, hill selection of seed, planting seed plots, green sprouting of seed, seed treatment to prevent scab and scurf, comparative tests of seed from various sources, use of fertilizers, closer planting on fertile soils, spraying with Bordeaux mixture and poison, and careful grading and storing.

Ten of the highest yielding strains of the late Petoskey or Russet Rural potato have been isolated and developed. Over 1,000 bushels of this high grade seed has been distributed to potato growers who will compare it with their own seed, and who will furnish the records of yield, etc.

The Michigan Potato Producers' Association through the assistance of the Potato Specialists inspected 269 acres of potatoes for certification. Of this number 192 acres passed the inspection and were certified. Approximately 26,000 bushels of certified potatoes were sold during the year. The primary object of the inspection and certification service is to improve the quality and yield of the potato crop in Michigan by eliminating low yielding strains, diseases, and undesirable varieties from the seed stock.

During last season six hundred bushels of Michigan certified seed potatoes have been placed in southern Michigan, Ohio, Indiana, Illinois and Iowa in demonstration plots. Through the cooperation of the Michigan Potato Producers' Association careful records will be kept of each plot. The object of this work is to compare the Michigan certified seed with seed from other sources.

In connection with the certification work 131 strains of Russet Rural and Green Mountain potatoes are being tested in a ten acre demonstration plot in one of the southern counties of the State.

Through the cooperation of the Michigan Potato Producers' Association ten bushels of Select Early Ohio and Irish Cobbler seed were secured from Minnesota and Wisconsin. Ten demonstration plots are planted with this seed. An effort is being made to develop a high yielding, disease free strain of early potatoes.

A variety test demonstration consisting of 29 varieties is planted on the horticultural grounds at the Michigan Agricultural College. Through the cooperation of the county agricultural agents over 20 seed plot demonstrations and four tuber-unit plots have been planted. Four seed treatment demonstrations; three planting date tests and four seed cutting demonstrations are planted. Five fertilizer and planting distance demonstrations have been started. Six spraying and three dusting demonstrations are being conducted.

The Michigan Potato Producers Association cooperating with the Extension Specialists will inspect this year approximately 1,100 acres of potatoes for certification.

SOILS.

The Extension schools which occupy the winter season, are usually held in cooperation with the county agent. The problems in which the farmer is most interested are discussed as fully as time will warrant. At a number of meetings samples of soils and marls are brought in by farmers and simple tests for acidity or lime contents are conducted, explaining where equipment for such work can be obtained, the reactions of tests and how such tests can be carried on by the farmer under field conditions.

The summer field work is divided into two divisions, namely the carrying on of accurately controlled demonstration plots and the field meetings held on such demonstration fields. The demonstration plots consist of work along the following lines: the use of commercial fertilizers of different kinds and amounts on various soil types; rate of application of manure and effect of reinforcing of manures with phosphate; different kinds and applications of limes and marls; the effect of fineness of division of ground limestone as covering a rotation; the use of various crops as green manure crops and their period of duration in the soil, and the effect of tillage operations on control of moisture and crop growth. Accurate records are kept of these projects not only for one year but for a number of years. Field records are also kept, the yields being taken by the field man rather than by the farmer or the person with whom we are cooperating. Field meetings are usually held on the demonstration plots during the growing season.

New work on different soil types and lime and fertilizer treatment on the catch and growth of alfalfa and clovers, as well as fertilizer demonstrations on corn, have been the principal lines of new work undertaken in the last year.

MUCK CROPS.

The service offered to owners of muck soils is based upon the fact that muck and peat soils have basic, physical and chemical factors not present in upland soils and consequently present different problems. The phases of work emphasized have been the determination of the agricultural adaptabilities of muck areas, fertilizer requirements of certain crops on certain types of muck, systems of farm management for muck lands, and problems of clearing, breaking, tilling and draining muck lands.

It has been the purpose to assemble all knowledge and experience relating to muck problems and make it available to owners of muck soils. In this effort the two phases of muck cropping have been kept in mind and that which applies to intensive culture of vegetable crops has not been confused with the extensive culture of general farm crops. In the absence of experimental data the most successful experiences of the best farmers have been depended upon, and supplemented with results from demonstration tests conducted cooperatively with them.

In general phosphorus and potash have been found to be the essential elements necessary for high limed mucks; while lime, nitrogen, phosphorus and potash are all necessary on the low limed mucks.

Because of its magnitude and need for help, special effort has been given to the celery industry. Assistance was given the growers in the choice of commercial fertilizers in regions previously depending upon Chicago manure

supplies. The savings as a result of home mixing and buying the right materials without nitrogen amounted to many thousands of dollars.

Southern Michigan and Northern Indiana produces 75% of the world mint. Mint is a muck crop. The application of phosphorus and potash increases the percentage of oil content. This fact has been extended through demonstrations located throughout the mint area. Assistance was given in the formation of the Michigan Muck Farmers' Association. This organization is composed of the better farmers and is an efficient avenue through which information is extended to its members.

The demonstrations conducted were planned and carried out on carefully laid out plots upon which observations could be made throughout the season and results obtained at the end of the season. The conclusions were pointed out to those who attended meetings held on the plots to observe results. In the celery area the main facts demonstrated were the value of potash and that all new muck will not grow celery without manure or mineral fertilizers, and that manure is not essential if proper commercial fertilizer is used.

In the Black River Valley demonstrations, the main principles demonstrated were the value of potash as the limiting element; the first resistant qualities of properly fed crops of sunflowers, sweet clover, sugar-beets, oats and peas; importance of rolling muck land; that sugar-beets can be successfully grown on muck, and that root crops are easily grown on muck.

FARM MANAGEMENT DEMONSTRATIONS.

Farm Management extension has for its purpose the securing of better organization and management of the individual farms, and helping to develop the program of the county agricultural agents along sound economic lines. The basis of the work is the financial records which farmers are influenced to keep and helped to analyze.

During the year the work was carried on in cooperation with county farm bureaus, granges and farmers' clubs. Farm accounting classes were conducted in cooperation with 33 county agents. The State Grange appointed a committee on accounting to cooperate with the College in this work. Through this committee 1,100 account books were distributed to members of local granges. A set of follow-up questionnaires were devised, and sent out to grange cooperators and from their replies cost data was secured on several important crops.

The account book was revised and 3,000 copies of the new edition have already been distributed.

INSECT CONTROL.

The season was largely occupied from May until September with a grasshopper invasion which covered about half of the State. Army-worms occupied our entire attention for about two weeks in various scattered, localities in the State. The grape leaf-hopper, grape-berry moth and rose-chafer in Van Buren and Berrien counties all received attention and in spite of everything that we could do severe losses were sustained.

Hessian-fly has been for several years on the increase, and considerable effort was made last fall to aid the farmers in avoiding loss because of this pest. Much time was also spent in searching out suspected invasions of European corn-borer; sod web-worm was usually found in place of this more dreaded pest. Some effort was expended along the line of lessening the loss due to codling-moth. This was done in cooperation with the Experiment

Station, also the same is true in regard to several greenhouse insects. In the southern part of the State the chinch-bug demanded some attention as also did the leaf-hopper on potatoes and some household insects, and mill insects. About two days of each month were expended in an effort to control the flat-headed tree-borer in cooperation with the Experiment Station.

Apiculture.

The purpose of this work has been to give instructions in all lines of beekeeping, with special reference to disease control. This instruction has been given to groups of beekeepers when possible, both by lecture, conversation and demonstration. Special effort has been made to give instructions in an apiary where various conditions could be pointed out, and suggestions made. Those present have often seen disease for the first time at such meetings and a demonstration of its treatment. The results of this work extend beyond those present, for when one man in a neighborhood learns to detect and treat disease, to use better methods, his neighbors, learning of his success, also adopt better methods.

During the winter months, one and two-day beekeepers' schools were held in twenty-four counties. The schools held early in the season, which was especially favorable to farm interests, were not largely attended, but as the season advanced the attendance and interest increased. Even a small group of beekeepers, giving two days to lectures and demonstrations means better beekeeping in that county. Miniature appliances, the blackboard and such equipment as we could secure from local beekeepers, were used for demonstration. In several places, young people from the high school attended the school. This suggests that some time of the specialist could very profitably be given to such schools as have agricultural instruction. This could be made a time and place to rally the local beekeepers.

This has not been so much a year of organizing, as strengthening and directing the activities of counties already organized. One county has been organized, which makes thirty-six counties with beekeepers' organizations. Other counties should be organized, especially in the north.

Several automobile tours have been made, with instruction and field demonstrations along the way. The interest taken and the opportunity will warrant much more of this kind of work.

HOUSEHOLD ENGINEERING AND DRAINAGE.

The drainage work which has been carried on during the last two years in St. Clair county was completed last year and has already shown results. About 22 carloads of tile were shipped to that county this last winter to be put in this spring, where, during previous years, practically no tile was ever used in the county. Four traction ditching machines are now operating in the county. The demonstration plots have produced very favorable results agriculturally.

Similar work has been started in Sanilac county this spring. However, economic conditions are somewhat adverse to arousing interest in this work. The price of tile has not become adjusted to the prices for farm crops and the farmer is naturally somewhat slow to purchase tile under present conditions. However, three or four demonstration plots have been lined up in that county and one meeting has been held and we expect by continuing this work we will arouse more interest in drainage.

Household engineering.

During this winter and spring, a model of our septic tank has been developed, and ten of these models have been placed with county agents. It is hoped that with the use of these models it will assist the county agents in explaining the construction and operation of the tank as well as assist those interested in building a tank. It is the plan to have these models passed around to the agents as they have occasion to use them. Already they have been made use of by fourteen of the county agents. Eleven demonstration septic tanks were constructed and about 200 plans were sent out. Plans were also prepared for a number of water systems and small water power plants.

MARKETING ORGANIZATIONS.

The work of the Markets department during the fiscal year was continued along the line of the policy to which the department has been committed for several years. This policy being simply, that, in response to demand from farmers for assistance in their marketing problems, efforts are made to organize farmers into permanent and substantial institutions for the purpose of undertaking any marketing or distribution functions which they may deem desirable or necessary.

This work may be divided into three classes:

(*First*) Assistance to a local corporation of farmers in establishing a local cooperative institution.

(*Second*) The combining of these local organizations into state or district commodity exchanges for the purpose of taking over some of the certain marketing or producing functions which the local associations have in common.

(*Third*) The working out of a comprehensive plan for uniting and harmonizing the commodity exchanges in the State through the Michigan State Farm Bureau and the re-organization of the latter in order to assume the coordinating functions of the commodity exchanges as well as the general state-wide activities for which the Farm Bureau was originally intended.

The assistance given to local organizations has covered practically all types, including cooperative elevator, potato, fruit and live stock associations, cooperative creameries and milk shipping and distributing associations. This work consists in the formulation of the proper working basis or by-laws, a cardinal feature of which is contractual relations. The adequate financing of local organizations is also a major problem in the solution of which assistance from the Markets department is being continually solicited. The general theory of cooperative enterprises in contra-distinction from capitalistic types of organizations is given important consideration.

The Michigan Potato Growers' Exchange now includes approximately 120 local organizations and has finished its third year of successful operation. This organization has handled a large percentage of the potato crop of Michigan and is without question the most important factor in the distribution of that crop. The institution now has a surplus of approximately $70,000 and is in sound financial condition.

The Michigan Live Stock Exchange now consists of 123 locals. This organization has thus far devoted its attention principally to transportation and rate problems, but has been studying carefully the sales problem in receiving markets, with a view of taking over the sales service as soon as the directors

of this organization think the project feasible. An effort is now being made to organize a stock company for the purpose of going into the commission business in the Detroit market. The live stock shipments from cooperative organizations now greatly outnumber receipts from commercial drovers. This organization is slowly maturing and is already a substantial factor in the protection of the live stock interests of Michigan.

The Fruit Growers Organization handled a very large volume of business during the last season and considerable progress has been made in maturing the present cooperative institution toward a more comprehensive and more powerful organization. Plans for the reorganization of the fruit interests have been carefully studied during the year. These plans include the uniting of the grape interest with the peach and apple growers' organizations and the still further organization of the smaller fruit interests, including cherries, berries and other bush fruits. To these three divisions a still further project includes the organization of district wide canning corporations directly associated with the selling organizations to be still further supplemented by cold storage facilities which are to be used for pre-cooling and for temporary storage for tree fruits. Completion of this project would place the Michigan fruit interests in the foreground in point of comprehensive organizations.

The principal attention of the Markets department, as regards commodity exchanges has been devoted to the completion of the Michigan State Farm Bureau Elevator Exchange. This organization was started during the year with an initial membership of 20 cooperative elevators and now has a total of 92 local members, with prospects of a total of 100 or over before the next annual meeting. This institution was like the Michigan Potato Growers' exchange and the Michigan Live Stock Exchange, without proto-types and naturally many difficulties were encountered in setting up a new organization of this type, for which there were no precedents. The Elevator Exchange is now, without question, the largest factor in handling the grain of the State and is generally considered by all concerned as being remarkably successful. The total volume of business for the month of June was approximately \$600,000. The estimated savings for cooperative elevators, on the basis of its present volume, is approximately \$100,000 per year.

The problem of developing some working arrangement between the Michigan State Farm Bureau and the several commodity exchanges in the State has been very difficult and has required more time and attention than all other marketing problems in the State combined.

The rather unique ambition of the Michigan State Farm Bureau to take on extensive economical activities, brought it into more or less direct conflict with the commodity exchanges already established, due to the co-extensive character of these organizations. The farm bureau as organized in Michigan, is of the mass type, being composed of all farmers without regard to the variation of their agricultural interests. Its government is based on representation from political divisions or counties.

The commodity exchanges on the contrary are combinations of local associations built around single or closely related commodity interests. These exchanges correspond largely to the districts or sections of the State best adapted to certain crops.

As the Farm Bureau membership is co-extensive with the management of the commodity organizations, conflict would be inevitable, provided that some plan was not arranged to harmonize Farm Bureau activities with the other organizations.

The following plan was developed which has for its purpose the uniting of the commodity exchanges with the Farm Bureau, allowing each exchange to participate in the management of the Farm Bureau by electing or nominating a director and by providing that these exchange directors should constitute a majority of the Board, thus assuring a unified policy.

The economic arrangement provides that each commodity exchange should have complete control of its own business activities, such as pertain exclusively to the commodity and that the exchanges should turn over to the Farm Bureau all functions that are state-wide in character or are common to all farm interests, such as legislation, traffic, general supplies, including feed, fertilizer, etc., and minor agricultural products.

The plan was adopted at the last annual meeting of the Farm Bureau and representation on its government body was anticipated by electing committeemen from the commodity exchanges. It is conceded that it will require another year before this plan can be thoroughly worked out. Further activities of the Farm Bureau provide for reciprocal relationship between commodity exchanges.

During the year increasingly less attention has been devoted to the organization of local associations by the Agent in Marketing and correspondingly more attention to problems of the commodity exchanges and the Michigan State Farm Bureau.

POULTRY HUSBANDRY.

The state-wide interest and enthusiasm manifested in economic poultry production has resulted largely from poultry culling work inaugurated in 1917, and maintained as the major extension project until the present time.

Poultry culling demonstrations and demonstration farms have repeatedly shown that intelligent culling is a big factor in economic egg production. thirty per cent of the hens maintained on our Michigan farms are unprofitable. This stupendous wastage can easily be avoided or reduced by eliminating according to physical tests as outlined in Extension bulletin No. 21.

PUBLICATIONS.

Edition.	Bulletin No.	Title.	No. pages.	Author.
30,000	19 Revised	Grasshopper control	2	R. H. Pettit.
5,000	25	Ext. course notes "Remodeling"	2	Home Econ. Dept.
10,000	Circular Reprint	Know your cows	4	J. A. Waldron.

CHANGES IN PERSONNEL.

	Title.	County.	Date of appointment.
Appointments.			
F. L. Simanton	County Agent	Berrien	July 1, 1920.
Stanley F. Wellman	County Agent	Lapeer	November 1, 1920.
Clair Taylor	County Agent	Montcalm	November 1, 1920.
V. C. Vaughan	County Agent	Leelanau	December 1, 1920.
Paul H. Smith	County Agent	Missaukee	January 1, 1921.
B. E. Shaffer	County Agent	Montcalm	January 1, 1921.
D. B. Jewell	County Agent	Cheboygan	February 15, 1921.
W. Floyd Mamby	County Agent	Iron	March 10, 1921.
J. V. Sheap	County Agent	Shiawassee	March 1, 1921.
R. D. Bailey	County Agent	Crawford	May 1, 1921.
C. M. McCrary	County Agent	Presque Isle	May 15, 1921.
Louise H. Campbell	State Leader, Home Econ.		December 1, 1920.
Harold Canfield	County Club Leader	Macomb	December 1, 1920.
C. E. Ackley	County Club Leader	Calhoun	January 1, 1921.
Mary V. Hall	County Club Leader	Iron	March 1, 1921.
Wm. C. Boman	County Club Leader	Wayne	May 1, 1921.
T. A. Farrand	Specialist, Horticulture		January 1, 1921.
Resignations.			
H. B. Blandford (Ass't)	County Agent		June 30, 1920.
H. L. Barnum	County Agent	Missaukee	September 1, 1920.
Gifford Patch, Jr.	County Agent	Montcalm	September 1, 1920.
R. A. Wiley	County Agent	Grand Traverse	October 31, 1920.
L. T. Bishop	County Agent	Lapeer	November 1, 1920.
S. J. Linck	County Agent	Muskegon	November 1, 1920.
C. L. Brody	County Agent	St. Clair	February 28, 1921.
H. E. Dennison	County Agent	Shiawassee	February 28, 1921.
E. S. Brewer	County Agent	Presque Isle	April 30, 1921.
Coral Havens	Specialist, Home Economics, Domestic Science		June 30, 1921.
Grace Hitchcock	Home Dem. Agent	Ottawa	October 31, 1920.
Clara Waldron	Home Dem. Agent	St. Clair	December 31, 1920.
Flora McElhinney	Home Dem. Agent	Houghton	February 28, 1921.
Wm. Anderson	Ass't Boys' and Girls' Clubs		December 31, 1920.
Margaret Hutty	Ass't Boys' and Girls' Clubs		February 28, 1921
G. O. Stewart	County Club Leader	Wayne	April 30, 1921.
K. B. Smith	County Club Leader	Genesee	June 1, 1921.
C. W. Waid	Specialist, Potatoes and Vegetables		April 1, 1921.
G. C. Raviler	Field Agent in Markets Organization		June 30, 1920.
Agents transferred.			
D. C. Long	County Agent	Iron to Muskegon	November 1, 1920.
I. B. McMurtry	County Agent	Cheboygan to Midland	November 1, 1920.
Clair Taylor	County Agent	Montcalm to Newaygo	January 1, 1921.
C. M. Kidman	County Agent	Cass to St. Clair	March 14, 1921.
E. L. Kunze	County Agent	Chippewa to Cass	June 1, 1921.
B. O. Hagerman	County Club Leader (Death of E. L. Lyons, former Club Leader, September 1, 1920)	Houghton to Washt'n'w	January 1, 1921.
I. T. Pickford	Specialist, Horticulture	to Oceana	November 1, 1920.
H. M. Eliot	Farm Manag. Demonstrator	to College Department	January 1, 1921.
Gifford Patch	County Agent	Montcalm to Markets	September 1, 1920.

The following is a statistical summary for the year as reported by project leaders. Duplications are unavoidable where more than one worker reports on meetings.

Number of farm visits	18,566
Number of demonstrations	745
Attendance	17,973
Number of lecture meetings	5,930
Attendance	321,882

The material of the foregoing report is quoted largely from annual reports submitted by department heads and extension specialists.

Very truly yours,

R. J. BALDWIN,

Extension Director.

BULLETINS

OF THE

Agricultural College Experiment Station

ISSUED DURING THE

YEAR ENDING JUNE 30, 1921.

SWEET CLOVER

Circular Bulletin No. 46.

C. R. MEGEE, FARM CROPS SECTION.

Sweet clover is rapidly gaining in favor in Michigan as a crop for building up soils low in fertility and organic matter; also for pasturage, hay, and as a seed and honey crop. When properly handled it furnishes abundant pasturage from early spring until late fall and seldom causes bloat. Though stock may not at first take readily to sweet clover, they will become accustomed to it if fed no other forage or roughage for a few days. On account of its succulence cattle often times crave dry roughage while being pastured on this crop.

Sweet clover will grow on soils that are quite low in fertility and deficient in organic matter, provided they are well supplied with lime. For this reason it is one of the best crops for building up light soils or poor heavily cropped soils that are low in fertility, whether the soil is light or heavy. If used as a green manuring crop it should be plowed under just before bloom, since at this stage the plant is full of water and decay will be rapid. Sweet clover as a green manuring crop has another advantage in that it decays much more rapidly than do many other crops when plowed under.

When properly handled, sweet clover hay contains practically as much digestible protein as alfalfa and more than red clover. The quality of milk produced when the hay is fed to cows is approximately the same as when other legumes are used, according to U. S. Farmers' Bulletin No. 820.

The yield of seed secured per acre is quite high when compared with alsike and red clover. When sown broadcast a yield from three to five bushels of seed per acre is not uncommon and when drilled in 32 inch rows yields of from 8 to 10 bushels are sometimes secured.

Sweet clover has long been recognized by bee-keepers as one of their valuable sources of nectar. The period of nectar secretion usually follows that of white and alsike clover. The honey from white sweet clover is light in color with a slight green tint and the yield is heavy.

VARIETIES OF SWEET CLOVER.

There are four important varieties of sweet clover. The white biennial is the one commonly referred to as ''sweet clover'' and has proven much better adapted to Michigan conditions than either the yellow biennial or yellow annual. The white biennial has a white blossom, an upright habit of growth, and matures seed the second year. The yellow biennial has

yellow blossoms, finer stems, is much more decumbent in habits of growth, and only yields from one-half to two-thirds as much as the white biennial. Seed of the white biennial is oftentimes adulterated with seed of the yellow biennial. This adulteration may be distinguished by the dark purplish green mottling and oftentimes purplish green spots on the seed of the yellow biennial. The yellow annual is a small erect growing plant, producing seed the first season and should not be sown in this State because of the very small growth secured. The seed of the yellow annual is much smaller than that of the other sweet clovers.

Seed of the white annual or ''Hughes Sweet clover'' (trade name Hubam Clover), is now being distributed over the State and shows promise of becoming a valuable crop.

LIME

Satisfactory yields are very seldom secured on acid soils. Even though the stand may be fair at first the plants will be stunted in growth and but a small amount of hay or pasturage secured. When the soil is in this condition it usually requires from one to two tons of ground limestone or from two to three cubic yards of marl to secure good results.

INOCULATION.

Since inoculation enables the plant to make use of atmospheric nitrogen it is very important to inoculate on soils low in organic matter and nitrogen. There are several different methods of inoculation. The pure culture and soil methods are the simplest and easiest to apply. Pure culture may be secured from the Department of Bacteriology, Michigan Agricultural College, East Lansing, Mich. The price is twenty-five cents per bottle and one bottle is sufficient for a bushel of seed. Directions for application accompany the bottle.

When it is not possible to secure the pure culture, very good results are usually obtained by the soil method. Dissolve one and one half ounces of carpenter glue in a quart of water and sprinkle over the seed which has been spread out on a smooth floor. Stir the seed and then scatter over the seed about a quart of soil that has been recently obtained from a sweet clover or alfalfa field where the roots have an abundance of nodules. Inoculation may also be made by broadcasting from two hundred to three hundred pounds of surface soil taken to a depth of three inches from a well inoculated field of sweet clover or alfalfa. The soil should be applied on a cloudy day or in the evening and immediately harrowed in.

SEEDING.

A greater growth and more lasting stand is usually secured *by seeding in the early spring on a well compacted seed bed. Loose seed beds are responsible for many failures.* Sweet clover may be seeded in the early spring on fall sown rye or wheat, or seeded with barley or oats. Only three-fourths of the usual amount of oats or barley should be sown when used as a nurse crop. From 12 to 15 pounds of scarified sweet clover seed per acre is usually sufficient to give a good stand. Scarification is important because the seed coat of the sweet clover seed is quite impervious to water and retards germination. From 16 to 18 pounds of unscarified seed or from 22 to 24 pounds of unhulled seed is usually sufficient to secure a stand.

On heavy fertile soils, sweet clover when seeded at the same time as the oats, sometimes makes sufficient growth to make difficult the curing of the grain. On this type of soil it is advisable to seed the sweet clover two weeks later than the oats.

HARVESTING FOR HAY.

The stage of growth at which sweet clover is cut has a great influence upon the quality of hay secured. *It should be cut just before the blossom buds appear.* After this stage sweet clover becomes very woody, the leaves fall off, and a very poor quality of hay results. When grown alone on fertile soils it is sometimes possible to secure a crop of hay the first season. The only precaution necessary is to cut early enough so that approximately from four to six inches growth will be made for winter protection.

The time and height of cutting is very important. Sweet clover does not propagate the second year from a crown as does alfalfa, but propagates from buds in the axils of the leaves on the lower portion of the stalk. Consequently if the first cutting is made below the young branches which bear the leaves, a second crop will not be secured. If the cutting is made just before the blossom buds appear the proper height will be about six inches, if however the plants are allowed to come into bloom it will be necessary to cut ten or twelve inches high in order that a second crop may be secured. If a ten inch stubble is desired it will be necessary to replace the shoe soles of the mower with higher soles which may be made of strap iron at any blacksmith shop.

HARVESTING FOR SEED.

The best implement to use in harvesting sweet clover for seed will depend upon the growth made. If the growth is not too rank and heavy, the grain binder may be used. However, if very rank the corn binder will give better satisfaction. A three foot swath may be cut with the corn binder by placing ten inch extensions upon the dividers. The mowing machine causes great loss through shattering and is not satisfactory. A sweet clover plant does not mature all of its seed at one time; consequently, the proper stage to cut is when three-fourths of the seed pods have turned brown.

Sweet clover may be threshed with the ordinary grain thresher. If very dry most of the seed will be hulled; if slightly damp but very few seed will be hulled. When the grain thresher does not remove the hull it may be hulled with a clover huller or scarifier. Due to the greater capacity of the grain thresher it is better adapted for threshing sweet clover than the clover huller.

HUBAM CLOVER

(Hughes Annual White Seed Clover)

Circular Bulletin No. 45.

J. F. COX, F. A. SPRAGG AND E. E. DOWN, FARM CROP SECTION.

Great interest is being taken in the new annual white sweet clover. Judging by results secured at the Michigan Agricultural College and at various points over the State, this new crop may become of importance in Michigan as a short season hay and pasture crop and as a crop to use in soil improvement. It is apparently well adapted to growing on light loams and may become a valuable crop on Michigan sandy loams and light loams deficient in organic matter. Bee men are also interested in the honey possibilities of this crop.

The possible agricultural value of the annual white sweet clover was first seen by Professor H. D. Hughes of the Iowa Experiment Station, who noticed annual plants in seed of sweet clover secured from Alabama. Mr. J. W. Nicolson with approval of Professor Hughes suggests the name ''Hubam'' as appropriately recognizing the discoverer and the source.

In 1918 Professor Hughes sent the Michigan Agricultural College a small envelope containing 100 seeds. This small amount was carefully increased. Enough seed was produced in 1919 to plant five and one-half acres at the Michigan Agricultural College, and a like acreage at various points over the State during the past season (1920). The college increase yielded approximately eight bushels per acre.

The G. R. & I. Sub-station at Howard City on a light sandy loam three-fourths of an acre, gave a yield of slightly over 10 bushels of unhulled seed, which cleaned to three bushels per acre. On the farm of Mr. Olaf Nelson of Aloha, Cheboygan county, an acre gave a yield of three bushels. Mr. L. L. Lawrence of Decatur, Van Buren county, secured 100 seeds from Professor Hughes three years ago, and harvested this year 157 pounds of cleaned seed. At the Chatham Experiment Station in Alger county, Upper Peninsula, the Hubam clover failed to mature seed, but produced an excellent forage growth.

In all cases observed the annual sweet clover, planted in early spring, produced an excellent forage growth by mid-July—a growth which apparently would yield from one and one-half to two tons of hay. It is finer stemmed and finer leafed than the common sweet clover. During the coming season the Farm Crops department will carry on experiments to determine the value of this crop seeded with small grains, grown alone for forage, pasturage, soil improvement, and seed purposes.

THE DISTRIBUTION OF SEED.

The supply of seed of this new crop is far from sufficient to meet the demand. The commercial price in the spring of 1921 ranged from $5.00 to $8.00 per

pound. The Farm Crops department is planning to distribute a large part of the recent increase to members of the Michigan Crop Improvement Association. It is important that the Hubam Clover be grown under a system of registration and field inspection, since there is apparently no way of telling its seed from that of the biennial type of white sweet clover.

Mr. J. W. Nicolson of the Farm Bureau Seed Department, Lansing, Mich., states that he will install machines for hulling, cleaning and scarifying the unhulled seed at service cost.

The Farm Crops department is charging $1.00 per pound for the seed to members of the Michigan Crop Improvement Association. Those who are interested in securing a small envelope of the Hubam Clover for trial can secure same on request, free of charge, from the Farm Crops department of the Michigan Agricultural College, East Lansing, as long as the supply set aside for this purpose holds out.

THE PLANTING OF SEED.

In planting for seed purposes it is recommended that seeding be made on corn, bean, or potato ground, or fallowed land which is in a firm, clean condition. If the soil is acid from one to two tons of finely ground limestone or several cubic yards of marl should be applied. Acid phosphate at the rate of two or three hundred pounds per acre will increase yield and hasten maturity.

Seed should be inoculated with culture which may be secured from the Department of Bacteriology of the Michigan Agricultural College, East Lansing, Mich. The price is 25 cents per bottle and one bottle contains sufficient material to inoculate a bushel of seed. Directions for application accompany the material, which is the same furnished for biennial sweet clover.

From one to two pounds of seed per acre, when drilled in rows 28 to 32 inches apart, about the middle of April, will apparently give maximum seed yields. The experience of the College indicates that one pound of seed per acre is enough, if properly planted. Care must be taken not to bury the seed, covering it as lightly as possible. Difficulty has been experienced in regulating the drill to sow the proper amount and therefore it is always necessary to test the drill on the floor, or on a sheet to insure a drop of one seed each inch, on an average, along the row. A Planet Junior, Columbia, or other type of garden drill may be used, and some makes of grain drills can be employed, using every fourth drill hole with cardboard partitions in seed box.

Other makes of grain drill will handle the seed in small enough quantity only through the seeder attachment. In that case the seed must be directed into the hoes and not sown broadcast. Seed may be mixed with cornmeal if the drill cannot be properly regulated for a small amount of seed. Most edge drop corn drills can be adapted to plant sweet clover, but not by means of the corn plates, as they are too thick. Most manufacturers make thinner plates to handle sorghums and other small seeds. These have an extra ring or plate to take up the extra space. For planting sweet clover with a plate three-sixteenths of an inch thick, there needs to be between 20 and 32 one-eighth inch holes. Two plates are needed.

During early growth the crop should be given clean cultivation with corn cultivator and weeded with hoe. Careful hand weeding as early as possible is essential to success in seed production.

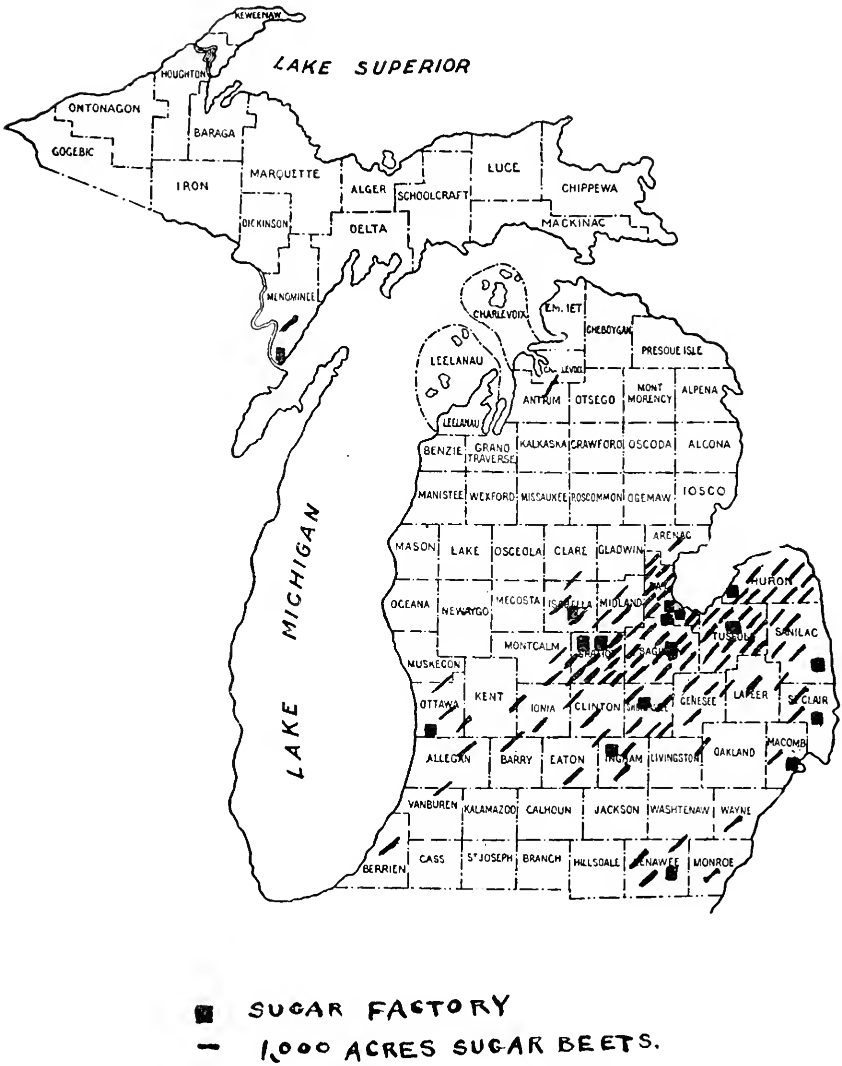
Harvesting is best accomplished by the use of an upright type of corn binder, doing the work in early morning or on days when the crop is damp, in order to avoid shattering. Seed matures in late September or early October. The crop requires about 150 days between seeding and harvest.

It is important not to have more than half of the seed pods brown at the time of harvesting, as the best seed will easily shatter in the wind and be lost It appears that when half of the seed pods are turning, the remainder will ripen satisfactorily in the shock. A satisfactory shock is of the long type, placing four bundles abreast instead of two. They stand up nicely and the bundles dry thoroughly.

Threshing is performed with an ordinary grain separator, the seed being hulled and cleaned by use of cloverhuller, scarifier and fanning mill. The Farm Bureau Seed department will hull, clean and scarify seed as it comes from thresher at cost charge.

There is not enough of the Hubam clover seed for forage or soil improvement purposes, other than experimentally this year. The present seed demands apparently warrant its production for seed purposes. It is very possible that this crop may become a highly important one in Michigan crop rotation, particularly on light soils.

Those desiring inspection of crop in field before harvest should notify Secretary A. L. Bibbins, of the Michigan Crop Improvement Association, East Lansing.



Map showing location of Michigan beet sugar factories and leading production areas.

MICHIGAN'S SUGAR FACTORIES

Columbia Sugar Company,

Bay City, Mich.
Mt. Pleasant, Mich.

Continental Sugar Company,

Blissfield, Mich.

Holland-St. Louis Sugar Company,

Holland, Mich.
St. Louis, Mich.

Independent Sugar Company,

Marine City, Mich.

Menominee River Sugar Company,

Menominee, Mich.

Michigan Sugar Company,

Bay City, Mich.
Alma, Mich.
Caro, Mich.
Carrolton, Mich.
Croswell, Mich.
Sebewaing, Mich.

Mt. Clemens Sugar Company,

Mt. Clemens, Mich.

Owosso Sugar Company,

Lansing, Mich.
Owosso, Mich.

West Bay City Sugar Company,

West Bay City, Mich.

SUGAR BEET GROWING IN MICHIGAN

Special Bulletin No. 106

J. F. COX and E. B. HILL, FARM CROPS SECTION

The production of sugar beets is one of Michigan's stable industries. It returns the growers, annually from $9,000,000 to $11,000,000 and requires a standing investment of over $30,000,000 in factories and equipment for sugar manufacture. Climatic conditions, proximity of markets and good transportation facilities prevailing throughout lower Michigan and the southern part of the Upper Peninsula are generally favorable to sugar beet production.

During average seasons an ample supply of properly distributed rainfall is assured, and the characteristic long summer days furnish ample sunlight and the right temperature (about 70% Fahrenheit average during June, July, and August) for the development of large yields of beets with a high sugar content. While the industry is substantially developed on suitable soils, it can be largely expanded to include extensive areas of adapted soil, not at present producing beets, in regions of proper climatic conditions, if expansion is encouraged by economic conditions.

The accompanying map shows the location of important Michigan sugar beet producing areas, and of beet sugar factories now in operation. Michigan ranks third in the United States in importance as a sugar beet producing state. It is the leading state in sugar production east of the Rocky Mountain region. Mr. V. H. Church, Crops Statistician of the U. S. Bureau of Crops Estimates, Lansing, Mich., gives the following statement of the yield and value of the Michigan sugar beet crop for the years 1909 to 1919:

MICHIGAN'S SUGAR BEET CROPS—1909 to 1919

YEAR.	Acres harvested.	Average yield per acre.	Total production, (000 omitted).	Average price.	Total value, (000 omitted).	Average value per acre.
	Acres.	Tons.	Tons.	Dollars.	Dollars.	Dollars.
1909	78,779	9 0	708	5.22	3,696	64.98
1910	117,500	10.3	1,208	6.00	7,248	61.80
1911	145,837	9 9	1,444	5.74	8,289	56.83
1912	124,241	6 8	839	5.69	4,774	38.69
1913	107,965	9.0	955	5.93	5,663	53.37
1914	101,263	8.5	857	5.23	4,482	44.45
1915	122,000	8.2	998	5.91	5,898	48.46
1916	99,619	5 5	544	6.14	3,337	33.77
1917	82,151	6 4	462	8.04	3,714	51.46
1918	114,976	7.9	890	10.08	8,971	79.63
1919	123,375	9.82	1,211	12.52	15,158	122.86
Average	110,700	8.3	920	6.95	6,476	59.66

In 1920, Michigan produced 129,400 acres of sugar beets which gave an average yield of 8.6 tons per acre and a total production of 1,106,000 tons. The average price per ton December 1st was $10.00, giving a total value of $11,060,000—an average of $85.47 per acre.

Sugar beet production and beet sugar manufacture are stable Michigan industries. Michigan ranks third as a sugar producing state.

THE SOIL FOR BEETS

Beets do best on fertile well drained loam, silt loam, and clay loam soils. Light loams and sandy loams will produce beets of high sugar content, but will not usually yield a sufficient tonnage per acre to justify expansion of production on these soils, except in cases where such soils are in an unusually high condition of fertility.

Certain muck soils tend to produce beets of a comparatively low sugar content, though yields may be good. If properly fertilized with potash and phosphoric acid, such soils may produce sugar beets of acceptable quality. It is the opinion of the Farm Crops department that

past experience in growing beets on muck land will hardly justify the inclusion of this type of soil in the area of soil best suited to extensive development for profitable sugar beet production. Investigation which may afford us more definite facts relative to growing beets on muck, are now under way by the Soils department.

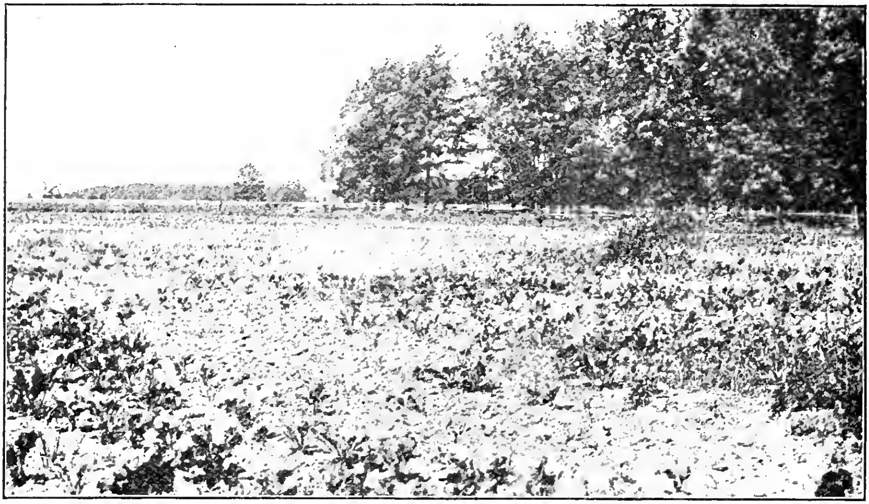
Sugar beets do best on fertile, well drained loam, silt loam and clay loam soils. Fall plowing to a good depth and thorough fitting provides conditions for the development of the best type of beet root.

Expansion in sugar beet growing when advisable should be directed to occupy additional areas of fertile and well drained loams, silt loams, and clay loams—soils which give both a high yield and a desirable sugar content, and of which extensive acreages are available. In addition there are large areas of poorly drained land of similar texture, adapted to beet growing when drained. The adequate drainage of such soils, now withheld from profitable sugar beet production due to poor drainage, would provide for a large expansion of beet growing under excellent soil and climatic conditions. Few crops will as rapidly repay the expense of tile drainage where needed as will the sugar beet crop.

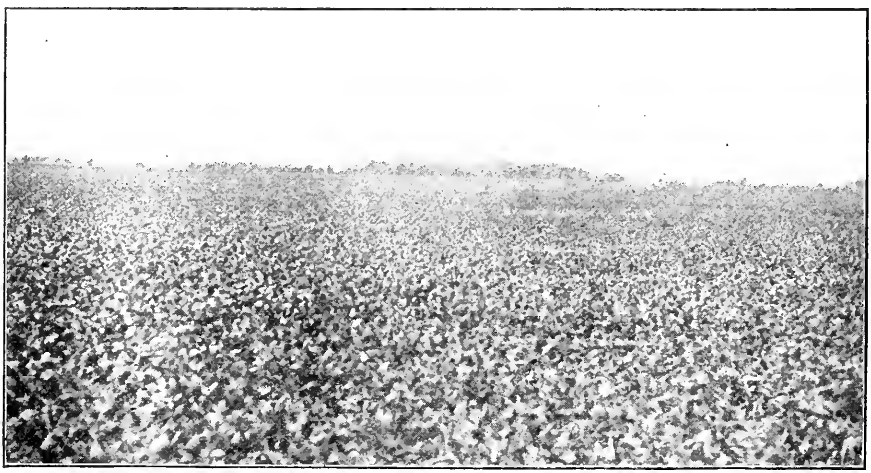
PREPARING LAND FOR BEETS.

Fall plowing to a good depth is conceded to be the best initial preparation for large sugar beet yields—the depth varies with soils—but under average Michigan conditions from 7 to 10 inches is considered sufficient. Do not plow more than three-quarters of an inch to one inch deeper than the usual depth at any one plowing. Increase the depth of plowing gradually—not all the same year. Fall plowing provides for the thorough settling of the furrow slice, and exposes the soil to winter action,

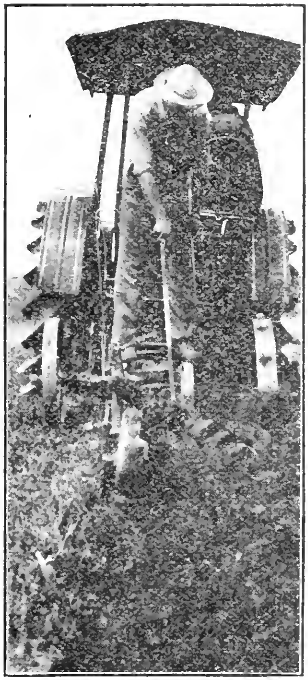
31



Poorly drained field above. Well drained field in same locality below. Tile drainage increases yields and insures the crop during wet seasons.



which controls insect pests and insures a proper mellowing. Fall plowed land is usually in condition to be readily worked into an excellent seed bed at an early date the following spring.



Fall plowing to good depth is the usual practice among good beet growers.

Where spring plowing is necessary it should be done as early as possible. *Discing before plowing in the spring is a great aid in preparing land for beets.* The loose ground on the surface from the discing helps to fill up the furrow bottom with fine material and thus makes it easier to prepare the seed bed. In view of the shorter period of time available for weather action spring plowing should not be so deep as fall plowing. It is not advisable to mix the sub-soil with the furrow slice in the spring; hence plowing should not be greater than the usual depth. After corn, potatoes, or beans, spring plowing to a medium depth is sufficient to provide proper conditions for the preparation of a good seed bed. For rapid and full development, beets need deep, easily penetrated, but not loose soil conditions. The surface must be worked into as near a "garden condition of tilth" as possible, in order to provide the best conditions for seedling development.

FERTILIZING THE BEET CROP

Under average Michigan soil conditions, sugar beets respond best to substantial applications of fertilizers high in phosphoric acid and potash. Growers report good results from the use of 300 to 500 pounds per acre of a complete fertilizer such as 2-12-2 or 2-10-4 or a like amount of acid phosphate. When this amount of fertilizer is used, it should be applied broadcast when fitting the seed bed, or harrowed in just before planting. When smaller applications, 100 to 125 pounds per acre are made, the fertilizer should be applied in the row usually with a special fertilizer attachment on the seeder. The common practice, which is a poor one, is to apply too little fertilizer of a low analysis for maximum returns per acre.

Sugar beets respond profitably to the proper use of fertilizer.
600 lbs. of 2-10-4 on right corner.
600 lbs. of 2-10-4 and manure in back ground.
Nothing on lower left corner.

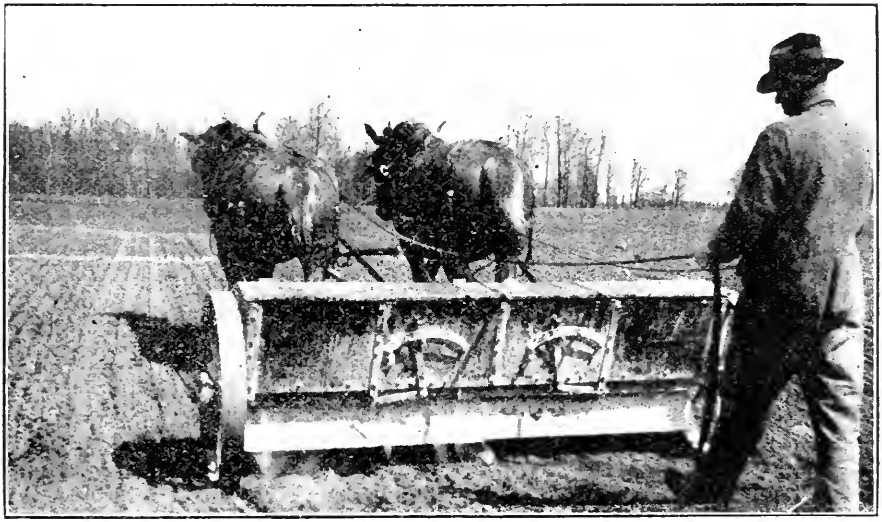
Barnyard manure is the most common fertilizer used on the farm today. It is very valuable in the production of a good crop. Barnyard manure, which has been applied the spring or fall the year previous to planting beets, gives the best results. Spring application of fresh manure immediately before planting is not recommended for several reasons: (1) The beet plant is not able to make the best use of this manure as it is not immediately available. (2) Heavy application of fresh manure may cause short, prongy, low yielding beets. (3) The spring top dressing of fresh manure, in many cases, is also a top dressing of weed seeds. This greatly increases the amount of labor necessary to care for the crop. Well rotted manure may profitably be applied in the spring.

Manure furnishes innumerable very valuable bacteria to the soil and

it also supplies a large amount of food for the bacteria with the result that the plant food is made available for the beets. It is best applied by means of a spreader at the rate of 8 to 12 loads per acre.

Manure should be supplemented with an application of acid phosphate, as above recommended, or of fertilizer high in phosphorus. As the price of potash declines, its use may again become more general.

On soils which are acid, sugar beet refuse lime at the rate of one to three tons per acre, or one to two tons of ground limestone applied in rotation, when fitting seed beds for corn or beets, will increase beet yields directly, and markedly increase the yields of clover and alfalfa following in rotation, thus providing a greater residue of organic matter and nitrogen, improving both the fertility and structure of the soil.



Heavy applications of commercial fertilizer pay well on beets. Fertilizer is conveniently applied when fitting the seed bed.

Refuse lime may be secured from the sugar companies. This lime is as good as can be secured for use in correcting soil acidity. On account of its physical condition, being somewhat moist and occasionally lumpy, it will not work through a lime distributer. Distribution is made from the wagon or piles by means of a fork or shovel or with manure spreader. The best time to apply this lime is in the fall or winter when the snow is not too deep.

The following table gives the analysis of two fairly representative samples of sugar beet factory refuse lime. Analysis made by Prof. A. J. Patten, Experiment Station Chemist.

Contents.	Sample No. 1.	Sample No. 2.
Moisture	37.40 per cent	....
Calcium and Magnesium Carbonate	49.96 per cent	79.84 per cent
Nitrogen	.18 per cent	.29 per cent
Phosphoric Acid (P2O5)	.39 per cent	.65 per cent
Potash (K2O)	.07 per cent	.09 per cent

The wide variance in analysis is due mainly to the difference in moisture content. Sample No. 1 contained over 37 per cent water, while sample No. 2 contained practically no moisture.

After the lime has served its purpose in the beet factory, in purifying the beet juices, it is washed out of the filter presses with large quantities of water. This thin mixture of lime and water is then run into a settling pond. Refuse lime taken directly from the settling pond is in rather poor physical condition with a great deal of moisture. A few factories have used their power shovel and transferred large amounts of this lime from the settling basin to piles on high ground. After remaining in these piles for two to five years, the lime has changed from a pasty condition to a drier mealy state, which is then in good shape for distribution on the soil with a manure spreader, fork or shovel.

In Europe, where the sugar beet industry has thrived for about 115 years, the sugar beet growers are allotted refuse lime in proportion to the tons of beets delivered. There is a clause in their beet contract providing for their allowance of lime. All this refuse lime, at the European factory, is usually cleaned up by three weeks after harvest.

Sugar beet refuse lime is a practical and cheap source of agricultural lime. Most sugar companies in Michigan make no charge for this lime in carload lots. The only cost to the beet grower is the actual loading charge at the factory and the freight to his station. The lime capacity of cars varies from 30 to 45 tons. Farmers may group together in the purchase of carloads.

There are great piles of this material, valuable for the correction of our sour soils, that are standing, unused, at the various sugar factories in the State. This waste material if properly used would add greatly to our agricultural prosperity.

Sugar companies also have each year a few car loads of fine dry air-slaked lime, which were not used in the purifying process. This lime accumulates from the lime burners. It is usually in excellent physical condition. Its analysis would be about the same as the hydrated lime purchased from commercial lime concerns.

In ordering carloads, it is first best to send for a sample, and thus avoid any misunderstanding.

FITTING THE SEED BED

The yield of beets depends very largely on the stand secured. A uniform stand can only be obtained by planting on a well fitted seed bed and giving proper attention to thinning and cultivating. The seed bed is the foundation of a good stand.

Fall plowed land can be fitted at an earlier date in the spring and offers a longer period for working into proper condition than spring plowed land. By discing, and harrowing frequently with a weighted spike tooth or a spring tooth harrow, such land can be best brought into a proper planting condition.

Spring plowed land should be firmed with a cultipacker or roller and harrowed immediately after plowing, and disced and harrowed at intervals until planting time. Discing before plowing improves the bottom of the furrow slice. The *final fitting immediately before planting* should be made with a spike tooth harrow or a heavy plank drag. Intensified effort in fitting the seed bed properly will be repaid by lessening the work of weed control after the crop is planted.

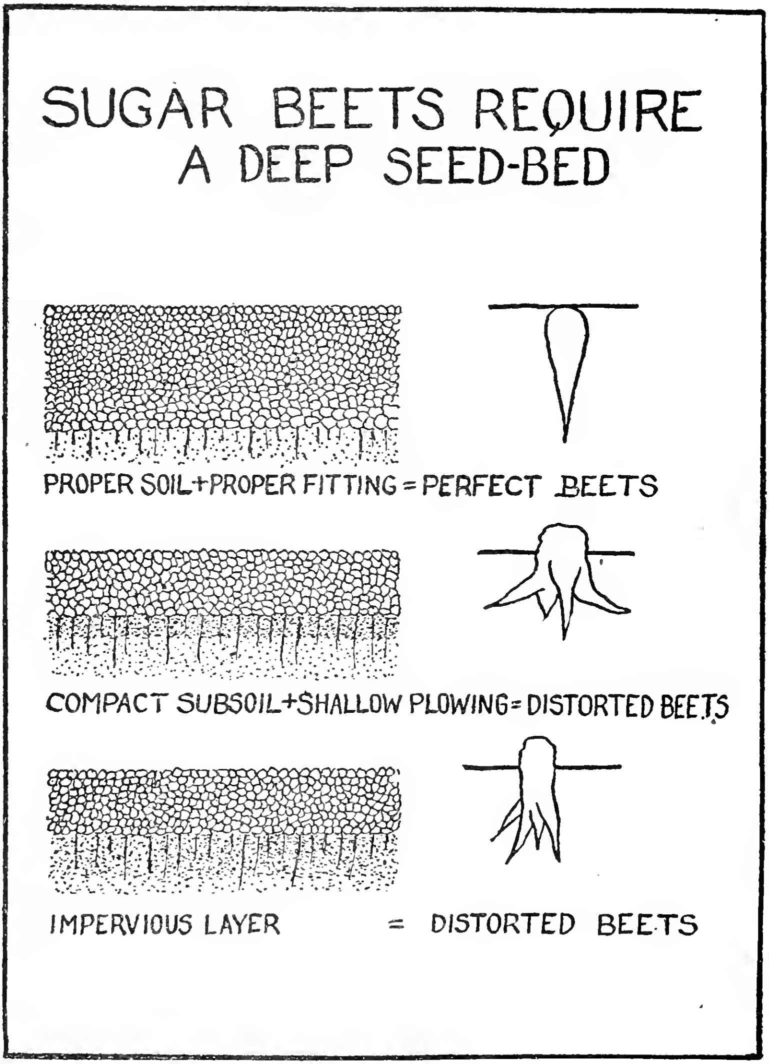
Thorough fitting greatly lessens the cost of later weed control when crop is growing.

PLANTING

Comparatively early planting on a well worked seed bed gives best results in yield and quality. Planting should be begun as early in May as the seed bed can be brought into condition and becomes properly warmed up. The usual planting period ranges from May 5th to 20th but plantings may be made as late as early June, where early planting is impossible.

The seed is drilled with a special beet drill, either a one, two or four row machine. The rows are usually from 22 to 24 inches apart and the seed is drilled at the rate of from 12 to 20 pounds per acre, according to the germination of the seed and the condition of the land. Rows 22 inches apart give highest yields on fertile soils. The average plantings are at the rate of 15 pounds per acre. Care should be taken in planting at a uniform depth of about one-half to three-fourths of an inch. In cases where the seed bed is exceptionally dry, owing to spring droughts, planting somewhat deeper—to one inch—may be advisable.

The use of a cultipacker after planting and before the beets are up, is recommended for ground which has a tendency to bake or crust over. In some cases it is the only means of saving the crop. The machine



Land for sugar beets should be plowed deeper than for most crops,—from seven to ten inches is considered sufficient. It is not best to plow more than three-quarters of an inch to one inch deeper than the usual depth, at one plowing. This deeper plowing should be done in the fall. Spring plowing should be at the usual depth.

breaks and cuts the hard crust which enables the seedling to break through the surface of the soil, thus helping to save a good stand.

The so-called sugar beet seed is a seed ball containing a number of individual seeds, several of which usually germinate, making it necessary to thin carefully by hand when plants are young.

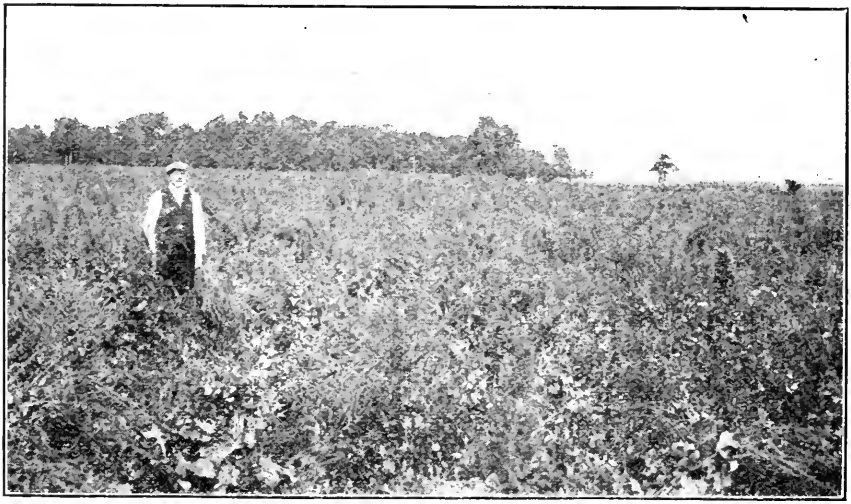
Sugar beet seed is usually supplied at cost by the sugar beet company, with whom the grower has a contract. Special effort is made to secure seed of high germination from high yielding strains which will produce sugar beets of high sugar content—an average of 13 per cent or above.

Sugar beet seed starts best on a well firmed seed bed in as near "garden tilth" as possible.

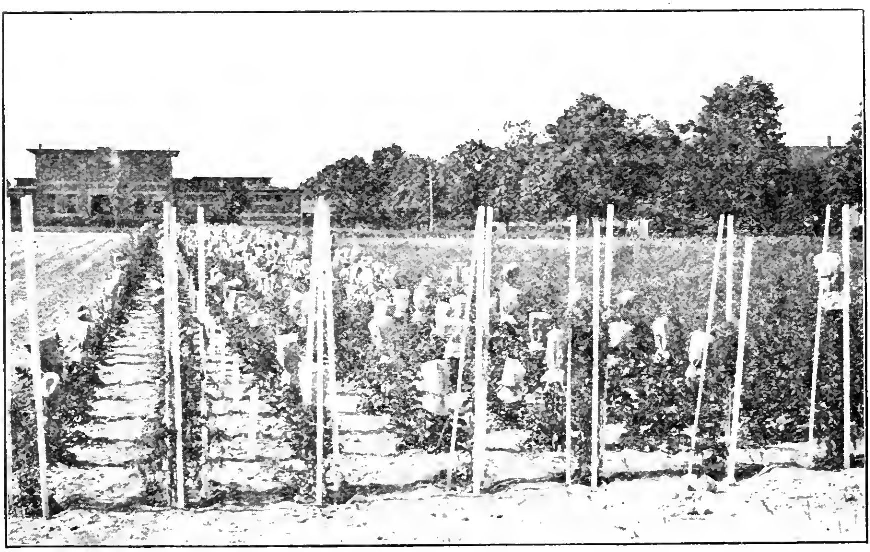
SEED PRODUCTION

Before the war practically all seed was imported, chiefly from Germany, most of it being of the Kleinwanzlebener variety. With the cutting off of the foreign supply during the war the home production of sugar beet seed became important, and several Michigan sugar companies produced one-half or more of the seed needed for their usual acreage. It was demonstrated that seed could be profitably produced by Michigan growers.

At the present time sugar beet seed production in Michigan is being largely discontinued with the opening up of a cheaper foreign supply, and due to the fact that the breeding of suitable mother beets (stechlings) was not developed as the foundation of seed production in Michigan. Such work is now under way at the Michigan Agricultural College and it is hoped that in the future the sugar beet seed industry in Michigan may make sound development with improved parent stock, selected for yield and high sugar content as a basis. A sufficient development in sugar beet seed production should be made in Michigan so that this phase of the sugar beet industry will be on a footing to develop rapidly and make the State independent of a foreign seed supply, should need again arise.



Sugar beet seed was grown successfully in Michigan during the recent war period.

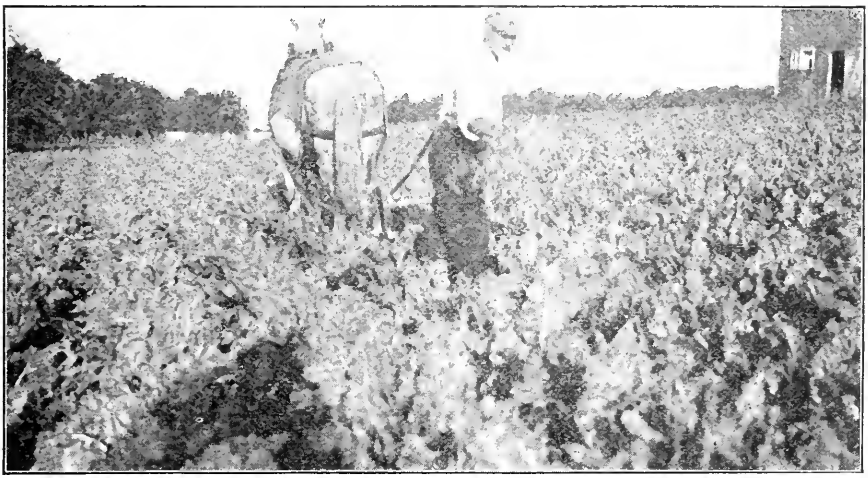


The future success of sugar beet seed production in Michigan will depend on a reliable source of high yielding mother strains of high sugar content. The above picture shows a beet breeding plat at the Michigan Experiment Station conducted by Prof. F. A. Spragg.

BLOCKING AND THINNING

The largest yield of beets of the right size for the highest sugar content results when plants are spaced from 10 to 12 inches apart in the row. It is important that the thinning be started and completed as soon as possible after the beet plants are large enough to work, at which time four leaves have developed. Yields are often reduced when thinning is delayed.

"Blocking" to tufts or bunches about 8 or 10 inches apart with a sharp bladed, seven inch hoe, is the first operation. The blade is drawn at right angles to the rows, beneath the surface of the ground so as to cut off the roots below the crowns. The bunches are then thinned carefully by hand to one plant. *It is important that the strongest bunches be left in blocking, and that in thinning the bunches, the most vigorous plant be left in place.*



Careful blocking and thinning insures a uniform stand. The grower shown above attributed his success in securing large beet yields to care in thinning the strongest plants and to careful fitting of the seed bed.

Careful attention to blocking and thinning will be repaid by a much more uniform stand and increased yields. Labor is usually paid on an acre basis for this work and hence there is a tendency for many to pull the larger plants, which handle easier, and leave the smaller and weaker ones in place. A bonus is sometimes paid the laborer by the grower for an increase of yield over a certain tonnage per acre. Children, unless carefully watched or instructed, are likely to reduce possible yields considerably by improper thinning.

HOEING AND CULTIVATING

The first cultivation should come immediately before blocking and thinning. In about 10 days to two weeks after blocking and thinning, the first hoeing should be made, the dirt being drawn carefully around the plants without covering the crowns. Cultipackers and rollers are often used, with good results, after blocking and thinning to smooth over and level off the dirt hoed into the middle of the row. This makes it much easier to cultivate in the proper manner the first time after blocking and thinning. Cultivation should be given every week or 10 days, until the beet leaves block the rows. Usually from four to six cultivations and two hoeings are necessary to keep a beet field free of weeds. The first and second cultivations should be close to the plants and may be fairly deep between rows, but later cultivation should be to shallow depth, or not more than two or three inches deep, so as not to prune the feeding roots of the beet plant, which tend to interlace between the rows near the surface after thirty-five or forty days' growth.

Clean cultivation is rewarded by thrifty growth and increased yields.

The cultivation of the beets is best handled by the use of the regular two or four-row beet cultivator. Disc or knife weeders and deer tongues may be used for the first two cultivations. After that remove disc weeders and use knife weeders and deer tongues, or deer tongues alone. Duck feet should be used with care as they are apt to cover up the beets and weeds in the beet row, thus making it difficult to do the hand work.

Beets should be cultivated once before thinning and four to five times after to keep the ground loose and retain the moisture. Do not be afraid to cultivate too many times. Many growers owe their good yields and

thus good profits to liberal and careful cultivation. Beets should not be hilled up, throw up just enough soil at the last cultivation to keep the top of the beet from being greened by the sun. A last cultivation should be made when the tops practically cover the row. Do not cultivate too deep or too close to the row at this time. A few leaves may be broken off, but this slight damage will be more than offset by the increased yield due to the tillage operation.

The careful grower cultivates close to the rows early in the season and gets all the weeds possible by means of machinery. Weeds should be thoroughly cleared out.

HARVESTING SUGAR BEETS

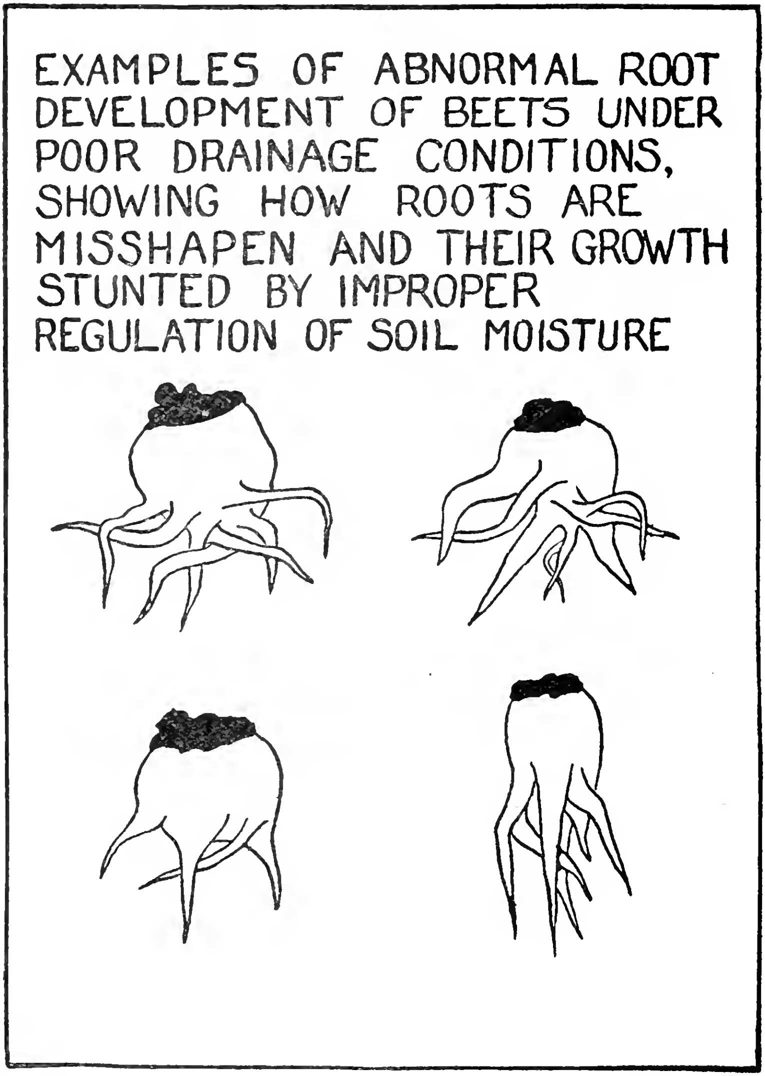
Since beets make rapid growth in the fall and store more sugar at that time, they should be left in the field until the right stage of maturity is reached. Maturity is indicated by the browning of the lower leaves, or by a wilted or drooping appearance of the plants. Tests of sugar content are made by factory experts, and notice is usually given to the grower as to when to begin harvest. Harvesting usually begins in late September and continues through October. A special harvesting implement, known as "a beet lifter" is used in raising the beets in the rows. Two types of beet lifters are in use. The older type has a single share which slides between the rows, slightly to one side, raising the beets during its passage; the other, a more efficient type, is equipped with two shares, which pass on either side of the row. Both implements raise the beets so that they are easily pulled by hand.

After lifting, the beets are pulled by hand, care being taken to knock off clinging dirt by striking the beets together, a bunch in each hand.

The usual practice is to throw the lifted beets from 16 to 18 rows into piles, the topping being done from the heaps so collected. A heavy regular beet topping knife is used in topping. The crowns are cut off at the base of the last leaf or slightly above the sun line. The topped beets are thrown into heaps and covered with tops to prevent excessive loss of moisture. As soon as possible they should be hauled to loading stations or factories to prevent drying and freezing. Repeated freezing and thawing makes sugar extraction difficult.

It is important both to the grower and manufacturer that beets be carefully topped. The crown and leaves of the sugar beet are relatively high in potash and phosphoric acid, and by retaining them on the land or feeding on the farm, much of the mineral fertility contained in the beet crop is returned. The salts contained in the crown prevent the proper crystalization in the process of sugar manufacture. Considering this, and the fact that the sugar content of that portion of the beet above ground is low, it is apparent that careful topping must be insisted upon by the manufacturer, and he is fully justified in deducting the amount of tare due to poor topping.

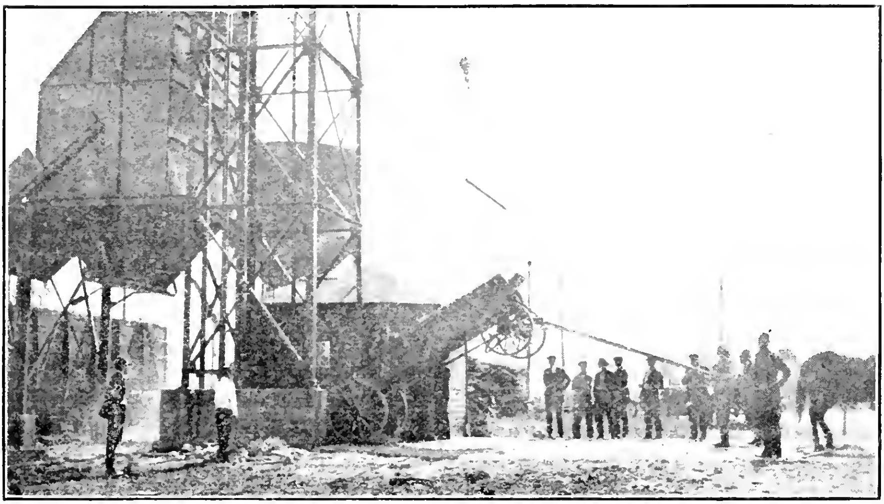
Average yields per acre range from 8 to 10 tons, but good growers frequently secure 12 to 14 tons and exceptional fields yield from 16 to 18 tons per acre.



Poor shaped beets are also caused by plowing under a tough sod or large amounts of barn yard manure, the spring of planting. They may also be formed by improper fitting of seed bed or by a hardpan at the bottom of furrow slice.

FEEDING BEET TOPS AND LEAVES

Beet tops and leaves furnish excellent feed for livestock. When left on the ground they may be profitably pastured with cattle or sheep. Care should be taken to turn the animals on beet tops for only short intervals, covering a period of several days, until they are accustomed to the feed. Too much beet tops and leaves, especially when somewhat frozen, may cause dairy stock or fattening cattle to scour, though if fed judiciously, a large part of the ration can be made up of tops and leaves with excellent results.



Wagon loads of beets are dumped at weighing stations by mechanical unloaders, which handle a load in from three to five minutes.

A better method of using tops and leaves is to ensile them, since the tramping of the livestock and the pasturing on the field will cause a loss of one-half or more of the feed and may, in wet seasons, puddle the land. Shallow, well drained pits are dug to a depth of two or three feet; a foot of straw is placed in bottom and then a foot of tops and leaves thrown in, then straw and tops repeated alternately; the whole is then covered with a foot or more of straw and enough dirt to keep the pile from freezing. By building up with alternate layers of tops and straw, a foot in thickness, the tops keep better and a better quality of feed is secured. One-third of the ration fed to dairy stock or one-half of the ration fed to fattening steers may be made up of beet tops and crowns with good results. Beet tops when properly fed are an excellent feed to stimulate the milk production of the dairy cow.

SUGAR BEETS IN ROTATION

The sugar beet crop is a valuable one in Michigan rotations on adapted soils. To produce a good crop of beets requires thorough fitting of the soil and careful cultivation, thus leaving the land in excellent condition without the need of plowing for a following crop of oats, barley, or spring wheat, or of rye, if the beets are removed sufficiently early. If the tops are returned to the soil, or manure from feeding the tops and pulp is applied to the land which produced the beet crop, less fertility is removed from the soil by beets than by any other Michigan cash crop.

*MINERAL FOOD REMOVED FROM THE SOIL BY BEETS AND OTHER CROPS.

Crop.	Yield.	Nitrogen.	Potash.	Phosphoric Acid.
Sugar beets	10 T.	30.0 lbs.	70.0 lbs.	14.0 lbs.
Potatoes	6 T.	47.0 "	76.5 "	21.5 "
Wheat	30 bu.	48.0 "	28.8 "	21.1 "
Barley	40 bu.	48.0 "	35.7 "	20.7 "
Oats	45 bu.	55.0 "	46.1 "	19.4 "
Corn	40 bu.	56.0 "	23.0 "	21.0 "

*From F. S. Harris, The Sugar Beet in America; Macmillan, New York.

A ten ton crop of beets will contain approximately 70 pounds of mineral elements (ash). From three or four tons of tops and leaves are produced containing 288 to 389 pounds of mineral elements (ash). From a fertility maintainence standpoint, it is important that the tops and leaves or manure produced from them be returned to the land.

As a cash crop, sugar beets are among the most profitable from the standpoint of the returns per acre. They require, however, a large amount of hand labor and ample provision must be made to provide for handling the crop.

It is usual for beets to be grown after corn, beans, or potatoes which leave the ground comparatively free of weeds. Clover sod plowed in the fall can be put in excellent shape for beets by proper fitting in the spring. Alfalfa or June grass (Kentucky Blue Grass) sods should be followed by a season in corn or beans before planting to beets, because of the expense involved in keeping down volunteer alfalfa or June grass.

It is not a good practice to grow beets year after year on the same land. Not only is fertility depleted and the organic content reduced, but great loss can be expected, due to fungus diseases such as the leaf spot, and insect injury, particularly from the root nematode.

Sugar beets are especially helpful in the rotation in cleaning up the land. The clean culture, hoeing and cultivating, given where beets are properly cared for, leaves the land in good shape for the following crops. When properly handled, farmers report success in controlling and eradicating quack grass by means of a beet crop. The important consideration in handling beets on land infested with quack grass is *frequent and careful* cultivation with a cultivator which will go close to the row and which

is equipped with the proper teeth. If poor cultivations are made, it is impossible to expect the labor to do good hand work under such conditions. A spring plowing should be made on quack infested land which is to be planted to beets. The land should also be summer-fallowed to a shallow depth the summer before. Keep in mind that to compete with this weed the grower must expect to put in an extra amount of careful labor.

THE FOLLOWING ROTATIONS INCLUDING SUGAR BEETS ARE SUGGESTED.

A. First year—clover; 2nd year—corn, beans or potatoes; 3rd year—beets; 4th year—oats, barley or rye, seeded to clover.

B. First year—clover; 2nd year—corn, beans, potatoes, or beets; 3rd year—oats, barley, rye, or wheat, seeded to clover; 4th year—clover; 5th year—beets corn, beans, or potatoes; 6th year—oats, barley, or rye, seeded to clover.

C. 1st year—corn, beans, potatoes; 2nd year—beets; 3rd year—oats or barley, seeded to alfalfa; 4th year—alfalfa; 5th year—alfalfa; 6th year—alfalfa.

A GOOD CROP OF GRAIN FOLLOWING SUGAR BEETS

Beets fit well in Michigan rotations. The clean and deep cultivation required in growing a crop of beets, leaves the land in excellent condition for a following crop of small grain (oats, barley, wheat, or rye). Lifting and pulling the beets thoroughly works the soil, making plowing for following crop unnecessary.

SUGAR BEET SUGGESTIONS

Grow beets on fertile loams, silt loams and clay loams.

Tile drain to increase yields and insure crop in wet seasons.

Fall plow to good depth.

Fit seed bed early and thoroughly.

Plant early—early to mid-May—in average season, in rows 22 to 24 inches apart.

Use enough fertilizer, 300 to 500 pounds of complete fertilizer or 300 pounds of acid phosphate with from 8 to 12 tons of well rotted manure per acre.

Lime with sugar beet lime, marl or ground limestone in rotation.

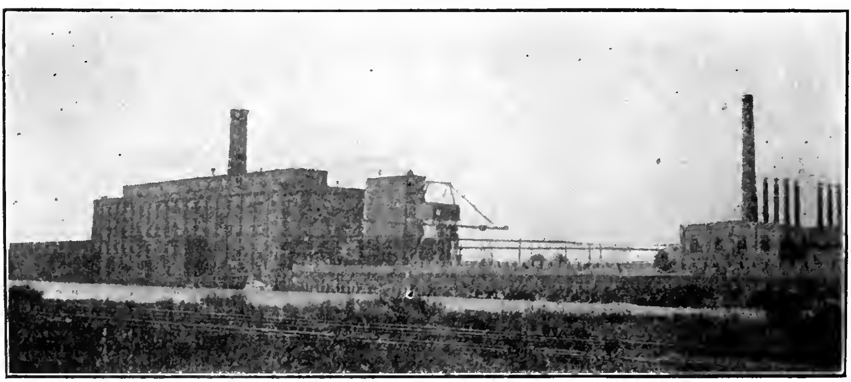
Thin carefully, blocking to vigorous bunches and thinning to strongest plant in bunch. Space plants from 10 to 12 inches apart.

Cultivate and hoe often enough to keep free of weeds.

Harvest when mature, as indicated by browning of bottom leaves and wilted appearance of plants.

Grow in good rotation to conserve and build up fertility and prevent loss from insects and diseases.

Feed tops and crowns and sugar beet pulp on the farm to conserve fertility.



A modern beet sugar factory will handle from 600 to 1,500 tons of beets per day, during the season's run of from 60 to 120 days

EUROPEAN CORN BORER

Circular Bulletin No. 44.

BY R. H. PETTIT, ENTOMOLOGICAL SECTION

As near as one can judge at this time, the most serious pest that has ever threatened the agriculture of America is the European corn borer. The corn crop is a very important one with us and the establishment of this new enemy in the great corn belt will undoubtedly cause great losses and greatly increase the cost of producing a bushel of corn and therefore affect all of our agricultural operations. Michigan stands in the path over which this insect is advancing from Canada to the great corn belt.

If we can retard or prevent the progress of this insect, we shall perform a patriotic duty of vast importance to the country at large, Michigan included. The European corn borer bores into the stalks, roots, ears, and cobs of corn and in celery, beets, fleshy and woody weeds like smart-weed, ragweed and others of that sort.

It is now established at St. Thomas, Canada, the nearest point reached in its western progress. It is also present in parts of New York, Pennsylvania, Massachusetts and New Hampshire.

The finding of a larva boring in corn does not necessarily mean that it is the dreaded pest, but any such case is open to suspicion.

Report any case of insects boring in any part of the corn plant to the Entomologist of the Experiment Station, East Lansing, Michigan, and do not try to send specimens unless so directed by that office. This is in order to avoid the risk of the package being broken in transit with the consequent liberation of the pest we are aiming to restrict. Furthermore a short description of the work will help materially in dealing with the case.

Address: R. H. Pettit,
Section of Entomology,
East Lansing, Mich.

FOREWORD

The first three papers of this bulletin represent the results of the efforts of Dr. H. J. Stafseth on the abortion problem for the year 1919. It is proper to state that the author began this work immediately upon terminating his connection with the Veterinary Corps of the U. S. Army after being out of touch with the problem for over two years, and finished his work rather abruptly because of a leave of absence granted him to enable him to accept a veterinary position with the Norwegian Government. None of the problems discussed in these papers is fully settled but for the reason indicated above it is thought advisable to offer this material for publication. Dr. Stafseth has made a distinct contribution to the scientific understanding of bovine infectious abortion as a result of his brief but careful and intensive studies.

Mr. I. Forest Huddleson, now in charge of the abortion investigations, is vigorously pursuing these same lines of research and reports on his findings in one of the projects in Part IV.

WARD GILTNER.

STUDIES IN INFECTIOUS ABORTION

Technical Bulletin No. 49.

Part I.

BY H. J. STAFSETH AND I. F. HUDDLESON.

On the presence of *Bacterium abortus* in the deeper layers of the mucous membrane of the non-gravid uteri.

INTRODUCTION.

The results of investigations on infectious abortion of cattle indicate that *Bact. abortus* may invade the uterus only during pregnancy and that after abortion or parturition it disappears from this organ within a relatively short period.

Cotton, W. E. (1) in 1913 stated that abortion bacilli may persist in the genital tract for as much as forty-six days after abortion.

Schroeder, E. C., and Cotton, W. E. (2) (1916) killed naturally infected, non-pregnant cows and examined the following organs, tissues and fluids for abortion bacilli: spleens, blood, livers, kidneys, brains, ovaries, uteri, udders, milk, synovial fluid from various joints, nerve tissues, lymph glands from all parts of the body etc. and found that in no case was *Bact. abortus* present in the uterus, "Although in all cases two or more quarters of the udder, the milk from the infected quarters, one or more supra-mammary lymph glands and in one instance some of the pelvic lymph glands were infected". "*Bact. abortus* injected into the non-pregnant uterus disappeared in the course of a few days." They add that one may find the abortion bacillus up to fifty days after abortion.

Again in 1919 Cotton, W. E. (3) makes the following statement: "The organism disappears from the uterus within a few weeks, commonly not to exceed two or three after abortion or parturition. It persists a longer time if the after-birth is retained than if the cow cleans properly." The longest time this investigator found it to persist in the uterus was fifty-one days. In order to determine whether abortion bacilli might be discharged with the estral fluid, large doses of *Bact. abortus* were injected intravenously shortly before estrum. Subsequent examinations of the estral fluid proved negative.

The findings of Schroeder and Cotton were substantiated by Giltner and Bandeen, (4) who found that the *Bact. abortus* disappeared from the uterus within twenty-one to twenty-eight days after abortion or parturition.

Thus, one may assume that the *Bact. abortus* does not permanently establish itself in the uterine cavity. However, knowing that certain pathogenic micro-organisms exist in the deeper layers of the skin and in the crypts of the tonsils and intestinal mucosa without any

apparent or gross harmful effects, although the tissues which they have invaded are ordinarily susceptible to the infectious characteristics of such organisms, one might ask this question: Is *Bact. abortus* able to penetrate into the deeper layers of the uterine mucous membrane and to remain there as the cause of a latent infection?

Hoping to throw some light on this question and incidentally further to substantiate the findings of other workers on the persistence of *Bact. abortus* in the genital tract, uteri from six cows, which were killed on account of failure to conceive, were examined in collaboration with Dr. E. T. Hallman of the Department of Animal Pathology. All these cows had aborted and came from herds badly infected with abortion disease. The complete history of each case will be included in a paper to be published by Dr. Hallman on the pathological side of this work. He (7) has already published a preliminary report on the pathology of the reproductive organs in sterility. In this paper there are given descriptions of the macroscopic and microscopic appearances of the diseased uterine mucosa and mention is made of the bacteria associated with the processes. In the present work the writer has attempted to make cultures from such portions of the uterine wall as are described by Dr. Hallman as being diseased.

The number of cases examined is rather small due to the fact that the proper kind of material for such work is very scarce. In order that the findings should carry the most possible weight the cows should come from herds where abortion is prevalent; they should have aborted and preferably developed more or less complications. Subsequent to abortion they should be non-pregnant at the time of slaughtering and abortion should have occurred not less than two months previously. Furthermore, the uteri should reach the laboratory in the very best of condition in order to facilitate the examination and to ensure the most accurate results. From this one can readily understand that no great amount of material would be available.

GENERAL TECHNIC.

The uteri were examined immediately upon being brought to the laboratory in all but two cases which were brought in so late that they had to be placed in the ice box over night. The serous surface of the uterine horns was seared with a hot iron and an incision made through the horns with a sterile scalpel. Through these incisions swabs were taken from the mucous membranes of the horns. In case any pus or other exudate was present samples of such material were obtained by means of sterile swabs or pipettes. The horns were then opened and the surface of the mucous membrane seared as before. Pieces of the seared mucous membrane of the size of a pea or small bean were now cut out from different places showing signs of pathological changes and ground in a mortar with sterile sand and physiological salt solution. As already noted an attempt was made to select areas showing the slight pathological processes often found in these cases of sterility (7).

Broth and agar tubes and plates were now inoculated with the various samples, the cultures divided into two batches and placed in the incubator at 37°C., one-half of the cultures being inoculated under aerobic and the other half under anaerobic conditions. The cultures

were watched daily and if not contaminated they were allowed to remain in the incubator for about fifteen days. Any plates or tubes showing abundant growth of any kind were taken out and examined. These, however, were few in number. Guinea pig inoculations were made from all samples obtained, the swabs being rinsed off in physiological salt solution. The pus and macerated tissues were diluted with salt solution to obtain a suitable suspension. At least two pigs were injected with the same material, one receiving 1 c.c. and the other 2 or 4 c.c. depending upon the nature of the inoculum. After thirty to thirty-six days the guinea pigs were killed and a careful autopsy made of each animal. Pieces of tissues were cut out of the spleen, liver, kidneys and testicles of each pig and placed on agar slants. Plates were also inoculated by making streaks across the surface with small pieces of tissue or a platinum wire. A blood sample was taken from each guinea pig and later tested with the complement fixation and agglutination test for *Bact. abortus* antibodies.

The following table shows the results obtained:

TABLE I.—SHOWING FINDINGS BY DIRECT CULTURE METHOD AND ANIMAL INOCULATION.

No. of animal	Origin of animal	Date of examination	Organisms obtained from surface swabs	Organisms obtained from deeper layers of mucosa	Organisms recovered from inoculated animals (1)
29	Farm A	March 3, 1919	Staph. pyog. aureus Staph. pyog. albus	Staph. pyog. aureus Staph. pyog. albus	Staph. pyog. albus
03	Farm A	March 3, 1919	Streptococcus	Streptococcus	Streptococcus
53	Farm A	March 3, 1919	Micrococcus B. subtilis	Micrococcus B. subtilis	None
5	Farm A	March 23, 1919	None	B. coli communior	None
8	Farm A	March 23, 1919	B. coli communis from pus in right horn	None	None
H. M.	Farm B	May 12, 1919	Trichobacterium	Trichobacterium	None

(1) Note—50 guinea pigs were inoculated with material from swabs, pus, and macerated tissues. Blood samples were taken from each animal at the time of autopsy and tested for *Bact. abortus* antibodies by the complement fixation and agglutination tests. The amounts of serum used in the complement fixation tests were .04; .02; .01; .005 c.c. In the agglutination test the following dilutions of serum were used: 1–50, 1–100, 1–200, 1–400. All tests were negative indicating complete absence of abortion bacilli.

DISCUSSION.

As our main object was to see if the *Bact. abortus* could be found in these organs, no effort was made to determine the microbial flora of the genital tract. Work along these lines has been conducted under the direction of Dr. Ward Giltner and a report of the results obtained was made by Keck in 1917 (5). During the years of 1918 and 1919 Giltner

and Bandeen made further bacteriological studies which gave additional information relative to the microbial flora of the genital organs of cattle.

It will be noticed from table 1 that none of the cases examined showed a great variety of organisms. In four cases the organisms obtained from the surface of the mucous membrane were also obtained from the deeper layers. In one case, *B. coli communior* was obtained from the deeper layers and not from the surface of the mucous membrane. In another case, *B. coli communis* was found in the pus of the right horn and not any other place. Only in two cases did we obtain any organisms from the tissues of the inoculated guinea pigs and those organisms were also found by the direct culture method. The blood samples from the guinea pigs were all negative to the complement fixation and agglutination tests for *Bact. abortus* antibodies.

CONCLUSIONS.

The cases examined are not sufficient in number to warrant us to draw any definite conclusions. However, in view of the fact that all the animals examined had aborted and came from herds where abortion was prevalent at the time when these cows were slaughtered, one may feel justified in considering the results obtained as additional evidence that the *Bact. abortus* does not persist indefinitely in the genital tract and does not penetrate into the deeper layers of the mucous membrane and remain there as a latent infection.

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Part II.

H. J. STAFSETH.

A few notes on the isolation and cultivation of *Bacterium abortus* with special reference to liver and spleen media.

INTRODUCTION.

To isolate *Bact. abortus* is not always an easy task and sometimes it is even more difficult to keep a recently isolated strain growing. One may obtain colonies which answer to the description of those of *Bact. abortus,* but may find it impossible or at least very hard to get satisfactory subcultures. This consequently retards the progress of abortion investigation. Abortion bacilli are usually found in association with other organisms which grow well on artificial media, and may thus outgrow the former and make it almost impossible to secure pure cultures.

Giltner (1) has called attention briefly to the use of media made from the uterine wall, fetal membranes, fetus and amniotic fluid. The last named was used successfully alone and with the addition of agar or gelatin or both. Huddleson (2) used the following:

Blood clot agar (blood clot one volume, water two volumes);
Ascitic agar (ascitic fluid taken from fetus);
Amniotic agar (fluid taken from amnion);
Fetal agar (aborted fetus ground and made up as meat infusion);
Glycerin agar and plain agar varying in degree of acidity.

He reports the following results: "*Bact. abortus* grew well on all media excepting glycerin agar, and plain agar made neutral or 1.5 acid to phenolphthalein. Plain meat infusion agar or blood clot agar made 1.2 acid to phenolphthalein are much more to be preferred for the growing of *Bact. abortus* owing to the fact that the organism can be isolated on these media without difficulty when anaerobic conditions are employed (Nowak). One should never attempt to isolate *Bact. abortus* without employing the anaerobic method. The writer has found that it is absolutely impossible to isolate the organism under aerobic conditions."

Smillie (3) has improved on the method of isolating abortion bacilli from mixed cultures through guinea pigs inasmuch as he has shown that this organism may be found in great numbers in the spleen of a guinea pig three to four weeks after inoculation. The method described by Smillie has been employed with success in this laboratory, but much time has often been wasted in trying to make subcultures grow satisfactorily. The direct culture method as described by Theobald Smith (4) has also been employed and has met with success as far as obtaining the first culture is concerned; but here again the same difficulty as that mentioned above was sometimes encountered. Although attempts to isolate new strains invariably were successful in the end, it was felt that if some medium could be made or some method devised, which would

further simplify and facilitate the isolation and subsequent cultivation of the abortion bacillus, much would be gained. With this point in mind some experiments have been carried out in this laboratory during the past six months with promising results.

EXPERIMENTAL WORK.

Employing the animal inoculation method as described by Smillie, it was found that when the tubes were placed in an anaerobic jar and the air was exhausted by a suction pump good growth was obtained in three to four days. The employment of an anaerobic jar in this way is more

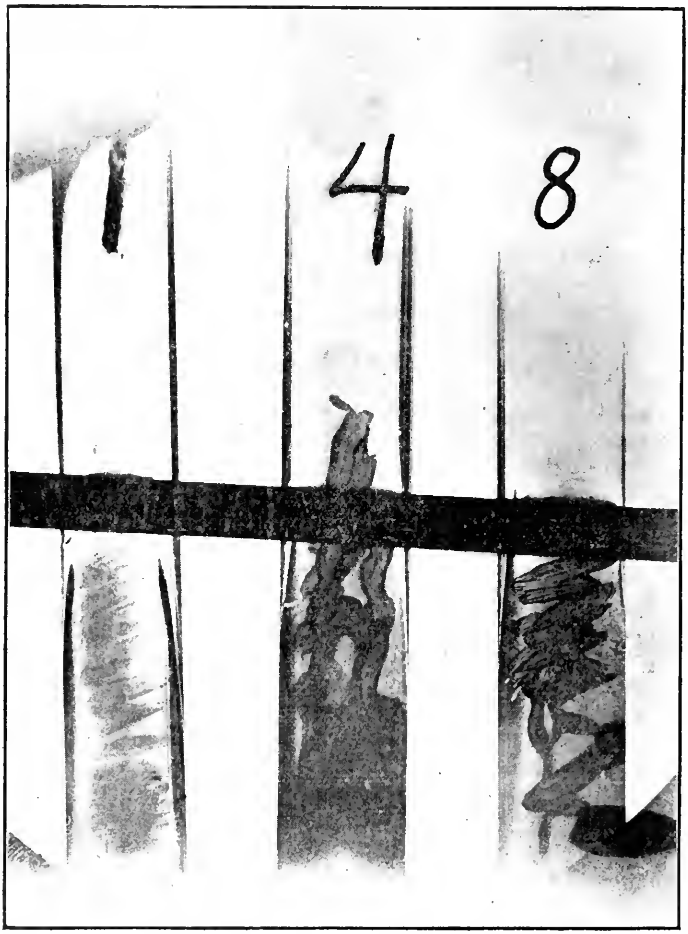

Figure I.

Fig. I shows the growth of a recently isolated strain on (1) plain agar, (4) spleen starch agar and (8) plain liver agar after incubating for fifty-two hours. These cultures were made from the first subculture obtained after the isolation of the strain.

efficient and far more convenient than to seal each tube separately with sealing wax. By placing the tubes next to the wall of the jar one can quite easily detect growth without having to open the jar. The growth obtained by this method was usually so abundant that heavy transplants could be made, thus making it easier to get growth on the first subculture. However, when transplants were made from the latter, the

Figure II.

Fig. II shows colonies of *Bact. abortus* grown on plain liver agar. This plate is one of eight plates made by making streaks with a platinum needle directly from the stomach contents of a five-months-old fetus. On six plates pure cultures were obtained while two showed slight contamination around the periphery. This plate had been incubated for seven days when the picture was taken. The abundance of growth and the size of the colonies show that such a long incubation would not have been necessary.

TABLE I.—SHOWING COMPARATIVE VALUE OF DIFFERENT MEDIA USING STOCK CULTURES.

	Kind of medium	1% dextrose 1% starch spleen agar	1% starch spleen agar	Plain spleen agar	1% dextrose 1% starch veal agar	1% starch veal agar	Plain veal agar	Bovim beef cube agar	1% dextrose 1% starch bovim beef cube agar	Plain liver
Bact. abortus Strain 15	Growth in 24 hrs	+	+ +	+	+	+	+	+ +	+ +	+ +
	Growth in 48 hrs	+ + +	+ + +	+ +	+ +	+ +	+	+ +	+ +	+ + +
	Growth in 72 hrs	+ + + +	+ + + +	+ + +	+ +	+ +	+	+ +	+ + +	+ + + +
	Growth in 96 hrs.	+ + + +	+ + + +	+ + +	+ +	+ +	+	+ +	+ + +	+ + + +
	Growth in 120 hrs.	+ + + +	+ + + +	+ + +	+ +	+ +	+	+ +	+ + +	+ + + +
	Growth in 144 hrs.	+ + + +	+ + + +	+ + +	+ +	+ +	+	+ +	+ + +	+ + + +
Bact. abortus Strain W	Growth in 24 hrs.	+	+ +	+	+	+	+	+	+ +	+ +
	Growth in 48 hrs.	+ + +	+ + +	+ + +	+	+ +	+ +	+	+ + +	+ + +
	Growth in 72 hrs.	+ + + +	+ + + +	+ + + +	+	+ + +	+ + +	+	+ + + +	+ + + +
	Growth in 96 hrs.	+ + + +	+ + + +	+ + + +	+	+ + +	+ + +	+	+ + + +	+ + + +
	Growth in 120 hrs.	+ + + +	+ + + +	+ + + +	+	+ + +	+ + +	+	+ + + +	+ + + +
	Growth in 144 hrs.	+ + + +	+ + + +	+ + + +	+	+ + +	+ + +	+	+ + +	+ + + +
Bact. abortus Strain XX	Growth in 24 hrs.	+	+ +	+ +	+	+ +	+ +	+ +	+ +	+ +
	Growth in 48 hrs.	+ + +	+ + +	+ + +	+	+ + +	+ + +	+ + +	+ +	+ + +
	Growth in 72 hrs.	+ + + +	+ + + +	+ + + +	+	+ + +	+ + + +	+ + +	+ +	+ + + +
	Growth in 96 hrs.	+ + + +	+ + + +	+ + + +	+	+ + +	+ + +	+ + +	+ +	+ + + +
	Growth in 120 hrs.	+ + + +	+ + + +	+ + + +	+	+ + +	+ + +	+ + +	+ +	+ + + +
	Growth in 144 hrs.	+ + + +	+ + + +	+ + + +	+	+ + +	+ + +	+ + +	+ +	+ + + +

+ = Slight growth; + + = Good growth; + + + = Very good growth; + + + + = Abundant growth.

growth was usually found to be exceedingly slow. By adding one per cent. starch or one per cent. dextrose or both to the medium, it was found that the growth would progress more rapidly. Later it was found that excellent growth could be obtained by employing spleen and liver media in place of beef. The composition of these media does not differ from that of ordinary beef agar except for the substitution of liver and spleen in the infusion in place of beef. The amount of spleen or liver added per liter of water is the same as that of beef. It was found that the spleen media were improved by the addition of one per cent. starch, or one per cent. dextrose or both; while the liver agar did not require the addition of carbohydrates.

In order to compare the value of various media for the cultivation of *Bact. abortus* three laboratory strains were selected and incubations made as shown in Table I.

Strain "W" has been in the laboratory for several years and has always grown well on artificial media. Strain 15 was isolated in 1916 and grew very poorly for six months or more previous to employing spleen and liver media.

Strain XX was isolated in the spring of 1919 and has grown about as well as the average of our laboratory strains.

SUMMARY.

Liver and spleen media have been employed in this laboratory by the writer for more than six months and have given good results. Strains of the abortion bacillus have been isolated more easily by the aid of these media. As is shown in Table I, there is very little or no difference between plain liver media and spleen media containing carbohydrates in the form of starch or dextrose.

Some strains have been found to possess certain idiosyncrasies, thus making it necessary to employ various media in order to find one that will produce the desired results. In some cases it may be necessary to make the first transplant from a newly isolated strain into broth, before being able to grow the organisms efficiently on agar slants.

The employment of *B. subtilis* as a means of producing anaerobiosis was found to be unnecessary as the use of a glass jar from which the air can be partly exhausted with a suction pump has given satisfactory results.

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Part III

H. J. STAFSETH.

On the possibility of differentiating between infected and immune animals in infectious abortion.

INTRODUCTION.

In studying the relation between pathogenic microorganisms and their hosts we find that three different conditions may exist, namely: 1. presence of microparasites on the skin or mucous membranes; 2. invasion of the tissues by the microparasites without the production of any sign of disease; and 3. infection, the condition in which morbid changes have resulted and symptoms of disease may be noticeable. Infection with some organisms results in a short time in the appearance of symptoms of a more or less alarming nature. In such cases the disease may be checked and serious consequences prevented. Other infections are insidious in their nature and no symptoms appear before it is too late to ward off the attack. In some of these infections the first sign of abnormality is a manifestation of the actual damage done. Infectious abortion comes under this class of diseases,—the dropping of the fetus is the sign of disease apparent to the owner; but in infectious abortion, we can conceive of all three of the above mentioned relationships between invader and host. The calf, the nonpregnant heifer and cows which are exposed to infection must surely be subject to surface contamination or to tissue invasion; while the pregnant animal probably being in a stage of susceptibility may contract the infection and show no outward manifestation thereof for weeks or months. Then with slight warning, the final manifestation of abortion may take place and we have gross evidence of disease. Some animals which are suceptible to a certain disease may develop a resistance but continue to harbor and to disseminate the organisms, thus endangering the safety of other animals. This condition is also recognized in infectious abortion.

In an effort to overcome the confusion that has existed for a long time relative to the naming of abortion disease, Giltner (1) has presented a defense of the term *infectious abortion* making it appear permissible to use this term to include all the manifold manifestations of the disease and its complications.

It is well known that animals infected with abortion bacilli will in most cases develop complement fixing and agglutinating antibodies, but the presence of these substances does not necessarily mean that an animal will expel her calf nor does the absence of such antibodies mean that it will not expel her calf. In the experimental herd, at this station, cows have carried normal calves to full term and yet their blood showed positive reactions to the complement fixation and agglutination tests. On the other hand there are cows in the same herd which showed the first positive test at or about the time of abortion. Then again there are cows which will give positive complement fixation and agglutination tests while there are good reasons to believe that

the infectious stage is past. These tests merely show then, that complement fixing and agglutination antibodies are present in the blood of such animals and since the tests mentioned are specific for *Bact. abortus* infection, it is certain that reacting animals are or have at some time been infected with this particular organism.

It has been suggested that before buying an animal it should be tested with one or both of these tests, and if the animal reacts one should not buy it. If that cow were immune and did not harbor the *Bact. abortus* in her body, would it not be safe to introduce her into any herd? Then again the cow might show negative tests and still abort after being placed into a new herd. Immunization with *Bact. abortus* vaccines and bacterines is being encouraged but is not yet fully accepted as a reliable means of prevention, and there is no test which will estimate the degree of immunity in the vaccinated animal.

It is difficult to accurately measure the value of immunizing agents in infectious abortion for a number of reasons. Results are very apt to be *post hoc non propter hoc* due to the development of a natural resistance with age or to an acquired immunity from previous invasions or infections by *Bact. abortus*. Furthermore, it is quite improper to estimate results wholly on the basis of fetuses lost or delivered prior to full term since the loss of the fetus is only one of the serious manifestations of abortion disease of cattle.

If some test could be perfected through which a distinction might be made between infected and immune animals it would greatly facilitate future research on infectious abortion. The work of Fleischner and Meyer (2) indicates that such a thing may be possible. These investigators found that guinea pigs infected with *Bact. abortus* gave a definite and specific reaction to the intradermal "abortin" test, while guinea pigs treated with a suspension of dead abortion bacilli failed to react. Both infected and injected (with dead organisms) pigs reacted to the complement fixation and agglutination tests. The intradermal "abortin" test had previously been employed by Reichel and Harkins (3) in cattle. After having examined three herds, a total of seventy animals, in which thirty-nine abortions had occurred they found that all animals reacted to either the complement fixation test or the agglutination test or both and twenty animals reacted to the intradermal "abortin" test. Five animals that reacted to the "abortin" test had not aborted but were from herds where abortion disease was prevalent. Herd No. B. consisting of five animals showed a normal history with no abortions, all animals showed reaction to one or both serum tests but none reacted to the intradermal test. In view of their results they concluded that, "With much to be desired in the application and interpretation of all the tests or means at hand to establish a diagnosis, the intradermal abortion test deserves recognition in that it can be applied by the veterinarian without assistance."

Experiments on the intradermal test were started by the writer in the early part of the summer of 1919 and the following data represent the results thus far obtained.

Experimental Work.

THE ABORTIN.

Two kinds of abortin were employed, namely: The alcohol-ether extract of *Bact. abortus* as prepared by Fleischner and Meyer (2) and the bacillary suspension of the same organisms as prepared by Reichel and Harkins (3). The latter is more easily prepared and was found to give better results than the former. In place of attempting to estimate the number of bacteria per cubic centimeter by counting the organisms, tube No. 7 of McFarland's nephelometer was selected as a standard for the opacity of the suspension. After finding that the suspension of dead bacilli produced better results than the alcohol ether extract the former was used exclusively.

APPLICATION OF THE INTRADERMAL TEST TO GUINEA PIGS.

An area of the abdomen of about three square cm. was clipped, shaved and disinfected. Into the skin of this area 0.1cc. of bacillary suspension was injected with a 27.5 gauge needle. A swelling of the size of a split pea should appear, the color of which should be characteristically whitish when working with light colored guinea pigs. This swelling should not have a tendency to disappear immediately nor to diffuse. If this occurs it is an indication that the material is being injected subcutaneously and the injection should be repeated in a different place. Readings are taken forty-eight hours after injection.

THE REACTION.

The reaction consists of an area of induration varying in size from 0.5cm. to 1.5cm. in diameter and appearing about 24 hours after the injection. In exceptional cases indurated areas of 2cm. in diameter have been found. At first a decided redness over the swelling is noticed in guinea pigs with light colored skin. As the induration increases the redness disappears and is followed by a color similar to that of cartilage. At the end of two or three days an area of necrosis appears in the center of the swelling. These areas of necrosis have been found to vary from 0.2 cm. to 1.5 cm. in diameter. Employing the alcohol-ether extract it was found that the reaction would appear and disappear more quickly than when the bacillary suspension was used. In cases where the former test fluid was used the reaction would be at its height at the forty-eighth hour and would be almost unnoticeable at the end of four to five days. When employing the latter preparation the reaction would as a rule gradually increase up to the fourth day and then gradually diminish, seldom disappearing entirely before the tenth day after the application of the test.

THE COMPLEMENT FIXATION TEST.

The method employed in the complement fixation test was that described in Giltner's Manual of General Bacteriology (4) with the following changes: A two per cent. suspension of blood cells was used in place of one per cent; two times the known titre of complement was used in the titration of antigen and the test proper; .04, .02, .01,, and .005 c. c. of

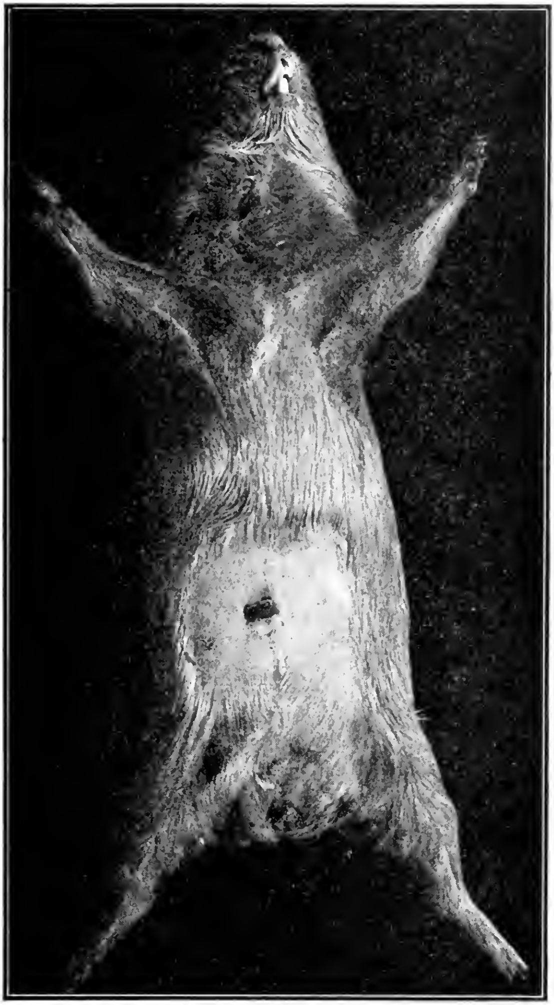

Figure I.—Guinea pig No. 73, Table 2, showing a rather extensive area of necrosis after the second or third day.

Figure II.—Guinea pig No. 79, Table 2, showing the average area of necrosis after the second or third day.

suspect serum was used in the order named instead of .01, .02, and .04 c. c. The tests were read after incubating for half an hour subsequent to the addition of hemolysin and blood cells. The hemolysin was produced by injecting 0.75, 1.5 and 3 c. c. of pure washed blood cells intravenously every other day then waiting seven days before bleeding. No glycerin was added to the antigen.

THE AGGLUTINATION TEST.

The antigen was prepared by growing several strains of *Bact. abortus* on plain agar for forty-eight hours, then washing off the slants with physiological salt solution containing phenol (0.5 per cent.) The antigen was diluted with physiological salt solution until the opacity of the bacterial suspension corresponded with 1.5 of McFarland's nephelometer. Two cubic centimeters of antigen were added to each of four tubes and 0.4, 0.2, 0.1 and 0.05 c. c. of serum diluted one to ten were added in the order named. The tubes were incubated for two hours at 37°C. then left at room temperature for twenty-four hours and readings taken at that time.

DETERMINATION OF SPECIFICITY OF THE INTRADERMAL TEST.

Series I.

Nine guinea pigs were given intraperitoneal injections of live cultures of *Bact. abortus*. Complement fixation, agglutination and intradermal tests were run eight, sixteen, twenty-four and thirty-two days after injection. Every animal developed positive reactions to all tests.

Series 2.

Nine guinea pigs were injected with a suspension of killed *Bact. abortus* for the purpose of immunization. Each pig received approximately two, four and eight billions of bacteria intraperitoneally at five-day intervals. Tests were run eight, sixteen, twenty-four and thirty-two days after the last injection. All pigs developed positive reaction to the complement fixation and agglutination tests while none reacted to the intradermal test.

Series 3 and 4.

The work recorded under series 1 and 2 was repeated using *B. typhosus* in place of *Bact. abortus*. While all of the eighteen pigs developed positive reactions to the agglutination test using typhoid bacilli as antigen, none reacted to the intradermal abortin test.

Series 5.

Nine pigs infected with *Bact. tuberculosis* were tested with the intradermal abortin test eight, sixteen, twenty-four, and thirty-two days after inoculation. None of these pigs reacted to the test. All pigs died of tuberculosis. One of these pigs died twenty days, and two of them about thirty days after inoculation.

EFFECT OF ATTEMPTED IMMUNIZATION ON THE INTRADERMAL REACTION.

In order to see if attempted immunization prior to or after infection would have any effect on the intradermal test, fifty-four guinea pigs were subjected to various treatments as shown in the following tables.

TABLE I.—EFFECT OF ATTEMPTED IMMUNIZATION FOLLOWING INFECTION.

No. of pigs	Date of infection	Nov. 21, 1919			Injected with dead cultures of abortion bacilli		Dec. 23, 1919			Jan. 6, 1920		
		Intradermal test	C. F. test	Aggl. test	Dec. 1, 1919	Dec. 8, 1919	Intradermal test	C. F. test	Aggl. test	Intradermal test	C. F. test	Aggl. test
58	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	Dead	....	....	....	....	....
59	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	Dead	....	....	....	....	....
60	Oct. 30, 1919	Dead	....	....	....	....	....	....	....	....	....	....
61	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	+	++++	++++	+	++++	++++
62	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	Dead	....	....	....	....	....
63	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	Dead	....	....	....	....	....
64	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	Dead	....	....	....	....	....
65	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	+	++++	++++	+	++++	++++
66	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	+	++++	++++	+	++++	++++
67	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	+	++++	++++	+	++++	++++
68	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	+	++++	++++	+	++++	++++
69	Oct. 30, 1919	+	++++	++++	1 bil.	2 bil.	Dead	....	....	....	....	....

\+ Indicates positive reaction.
++++ Indicates degree of reaction, meaning that complement fixation and agglutination took place in all four tubes in each test.

TABLE NO. II.—EFFECT OF ATTEMPTED IMMUNIZATION PRIOR TO INFECTION.

No. of pig	Injected with dead cultures of abortion bacilli			Nov. 25, 1919			Infected or exposed Nov. 28, 1919	Dec. 19, 1919			Jan. 6, 1920		
	Oct. 30, 1919	Nov. 6 1919	Nov. 13, 1919	Intradermal test	C. F. test	Aggl. test		Intradermal test	C. F. test	Aggl. test	Intradermal test	C. F. test	Aggl. test
70	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	2 bil. live B. ab. intraperitoneally	+	+ + + +	+ + + +	Dead	....	....
71	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	2 bil. live B. ab. intraperitoneally	+	+ + + +	+ + + +	+	+ + + +	+ + + +
72	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	2 bil. live B. ab. intraperitoneally	+	+ + + +	+ + + +	+	+ + + +	+ + + +
73	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	Fed. live B. ab.	+	+ + + +	+ + + +	*	....	....
74	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	Fed. live B. ab.	+	+ + + +	+ + + +	+	+ + + +	+ + + +
75	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	Fed. live B. ab.	+	+ + + +	+ + + +	+	+ + + +	+ + + +
76	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	2 bil. live B. ab. intraperitoneally	+	+ + + +	+ + + +	+	+ + + +	+ + + +
77	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	2 bil. live B. ab. intraperitoneally	+	+ + + +	+ + + +	+	+ + + +	+ + + +
78	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	2 bil. live B. ab. intraperitoneally	+	+ + + +	+ + + +	+	+ + + +	+ + + +
79	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	Fed. live B. ab.	+	+ + + +	+ + + +	*	....	....
80	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	Fed. live B. ab.	+	+ + + +	+ + + +	+	+ + + +	+ + + +
81	1 bil.	2 bil.	4 bil.	—	+ + + +	+ + + +	Fed. live B. ab.	+	+ + + +	+ + + +	+	+ + + +	+ + + +

— Indicates no reaction; + Indicates positive reaction. + + + + (See Table I.)
* Killed in order to obtain photograph of reaction.
Note:—Pigs 58 to 81 inclusive were kept in wire cages, each cage holding three pigs.

TABLE NO. III—CONTROLS

No. of pig	Nov. 27, 1919			Nov. 29, 1919	Dec. 19, 1919			Jan. 6, 1920		
	Intradermal test	C. F. test	Aggl. test		Intradermal test	C. F. test	Aggl. test	Intradermal test	C. F. test	Aggl. test
86	–	–	–	Live suspension of Bact. abortus sprinkled on feed	+	++++	+++	+	++++	++++
83	–	–	–	Live suspension of Bact. abortus sprinkled on feed	+	++	–	+	++++	++++
85	–	–	–	Live suspension of Bact. abortus sprinkled on feed	+	++++	+	+	++++	++++
82	–	–	–	Not exposed	–	–	–	+	++	+
84	–	–	–	Not exposed	±	+	–	+	++++	++
87	–	–	–	Not exposed	–	–	–	+	+++	++

+ Indicates reaction
– Indicates no reaction.
± Indicates slight reaction.
++++; +++; ++; + Indicates degree of reaction.

TABLE No. IV.—EFFECT OF ATTEMPTED IMMUNIZATION WITH LIPO-VACCINE PRIOR TO INFECTION.

No. of pig	Date of injection (1)	Date of infection (2)	Oct. 24, 1919			Dec. 12, 1919			Jan. 6, 1920
			Intradermal test	C. P. test	Aggl. test	Intradermal test	C. F. test	Aggl. test	Intradermal test
1 female....	September 2, 1919............	October 4, 1919..............	+	++++	++++	+	++++	++++	+
2 female....	September 2, 1919............	October 4, 1919..............	+	++++	++++	+	++++	++++	Dead
3 female....	September 2, 1919............	October 4, 1919..............	Aborted and died Oct. 5.....		....	....	++++	++++	Dead
4 female....	September 2, 1919............	October 4, 1919..............	+	++++	++++	+	++++	++++	Dead
5 female....	September 2, 1919............	October 4, 1919..............	+	++++	++++	+	++++	++++	Dead
6 female....	September 2, 1919............	October 4, 1919..............	+	++++	++++	+	++++	++++	+
7 female....	September 2, 1919............	October 4, 1919..............	+	++++	++++	+	++++	++++	+
8 female....	September 2, 1919............	October 4, 1919..............	+	++++	++++	+	++++	++++	+
9 female....	September 2, 1919............	October 4, 1919..............	+	++++	++++	+	++++	++++	+
10 female....	September 2, 1919............	Dead......................	....	....	....	....	....	....	....
11 male.....	Not injected.................	Not infected..............	−	−	−	+	++++	++	+
12 male.....	Not injected.................	Not infected..............	−	−	+	+	++++	++	+

(1) 1 cc of lipo-vaccine was injected subcutaneously. This vaccine contained approximately 4 billion abortion bacilli, 2 billion *Staph. pyogenes aureus*, 2 billion *Staph. pyogenes albus* and 1 billion *B. coli communis*.

(2) Each pig was given about one billion live abortion bacilli intraperitonically.

Note:—A series of pigs (No. 6) consisting of 10 females and 2 males was placed in a separate pen Sept. 2, 1919 and the females were infected on the same day (Oct. 4, 1919) and in the same way as the females in table 4. Tests were run on both series on the same day, and the results obtained by the complement fixation, agglutination and intradermal tests corresponded closely in both series.

++++ and + (See table II).

DISCUSSION.

The results obtained in series 1, 2, 3, 4, and 5 show that guinea pigs infected with *Bact. abortus* will react to the intradermal abortin test while those which are treated with dead cultures only fail to react. The results also indicate that the reaction is specific for *Bact. abortus* infection since pigs subjected to treatments with live or dead typhoid bacilli and live tubercle bacilli showed no reaction to *Bact. abortus* antigens whatever.

Tables 1, 2, and 4 and series 6 show that treatment with dead cultures of *Bact. abortus,* whether administered before or after infection, does not in any way prevent the development of cutaneous hypersensitiveness. It is also evident that this treatment does not protect guinea pigs against infection through injection or ingestion of live cultures if the intradermal test is a true index of infection. In table 3, there is an apparent discrepancy as pigs 82, 84, and 87 which were not intentionally exposed to infection by the writer developed positive reactions to all tests. This, however, may easily be accounted for as the two cages in which these pigs were kept stood so close together that infection might readily be carried from one cage to the other with dust or straw, which the pigs might kick through the wire netting. The extreme susceptibility of the guinea pig to *Bact. abortus* infection is brought out by this occurrence, as the amount of live culture introduced into the first cage was very small.

In analyzing the results obtained in table 4 and series No. 6 it will be noticed that the four males placed with the females developed positive reactions to all tests employed. This shows that guinea pigs, which are infected with *Bact. abortus,* must discharge the organism, as the infection of the males could be explained in no other way. Great care was exercised not to bring any infection into these pens. The fact that the treated (with lipo-vaccine) females listed in table 4 raised nine young pigs between Oct. 4, 1919, and Jan. 6, 1920, while the females in series 6, failed to raise a single one may be of some significance. Abortions occurred in both pens due possibly to handling while in advanced pregnancy, but as will be noticed from table 4, the pigs were not handled very often.

Many of the guinea pigs in these experiments became very much emaciated and showed signs of paralysis or extreme weakness. This was especially true of those pigs which were treated with dead cultures subsequent to infection.

The exact cause of this is not known, nor will an examination be attempted at this time. Some of the females in series 6 and two or three of those listed in table 4 showed signs of this same affection. Several of them died, but those which recovered from the first effects of the treatments developed no untoward after effects.

In view of this work, it appears that the general condition of an animal as regards infection and the condition of the uterus as regards abortion do not correspond. If the lipo-vaccine was instrumental in protecting the females, which gave birth to and raised the nine normal pigs, against the harmful effect of the abortion bacillus, the local evidence of this fact is the absence of abortions and the systemic evidence the production of complement fixing and agglutination antibodies. The

protection could not be anti-bacterial as the pigs continued to discharge abortion bacilli as evidence by the infection of the males. Furthermore the intradermal test indicates the presence of live abortion organisms in the body, as it has been shown throughout this work that positive reaction to the intradermal abortin test develops only as a result of infection with the abortus bacillus.

The fact that an animal once has been infected does not mean that it will continue always to react to the intradermal test. This is indicated by experiments performed on cattle. Three calves were tested shortly after being born by the serum and intradermal tests. Two were positive to all tests and one was negative. The latter was then infected with *Bact. abortus* by intravenous injection and developed positive reactions to a very marked degree to all tests. On repeated testing it was found that all three animals ceased reacting to the intradermal test. The two naturally infected calves reacted to the intradermal test some time after the reaction to the other tests had disappeared. In one case an intradermal reaction was obtained three months after the other tests had become negative. When the animal was tested six weeks later, it was found negative. The artificially infected calf was a male, while the other two were females. The former showed positive complement fixation and agglutination tests after the intradermal test failed to produce a reaction. The complement fixing and agglutinating antibodies were, however, diminishing quite noticeably as evidenced by weaker reactions. These results support the idea that a permanent infection in calves is improbable.

Complement fixation and agglutination tests were run on the blood sera and milk of several cows. Bacteriological examinations in the form of guinea pig inoculations were also made of the milk from these cows. The work on the milk was done by Huddleson of this laboratory. Intradermal tests run on these cows compared with the other tests and examinations suggest that this test may be employed as a means of detecting the animals which harbor live abortion organisms in their bodies. However, the work in cattle has not progressed sufficiently to warrant any definite conclusions. Work along these lines will be continued by Mr. Huddleson and it is hoped that the test may be perfected so that the carrier of *Bact. abortus* can be detected and distinguished from the animals which merely have the abortion antibodies in their serum.

Reichel and Harkins (3) tested seventy animals and all reacted to either one or both of the complement fixation and agglutination tests while only twenty reacted to the intradermal test. Out of the three herds tested, one herd showed a normal history while in the other two abortions had occurred. In all, thirty-seven animals had aborted, one having aborted three times. Might it not be possible that the thirty-seven animals in those herds were the ones which were actually infected, while the others were immune? If surface presence or tissue invasion, pure and simple, are possible with the *Bact. abortus,* then it is questionable whether the intradermal test would detect such a condition. Would the agglutination and complement fixation test detect? On the other hand, it seems within reason to believe that an infection may be detected by this test in cattle as well as in guinea pigs.

CONCLUSIONS.

1. The intradermal abortion test is a reliable and specific test for *Bact. abortus* infection in guinea pigs.
2. Guinea pigs injected with dead cultures of *Bact. abortus* do not react to the intradermal abortin test.
3. The physiological salt suspension of *Bact. abortus* is the best type of abortin so far employed.
4. Treatment with dead cultures before or after infection does not affect the intradermal reaction.
5. Treatment with dead cultures does not protect guinea pigs against infection with *Bact. abortus*.
6. Detection of infectious abortion in cattle may be possible by means of the intradermal abortin test.

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STUDIES IN INFECTIOUS ABORTION.

The Isolation of *Bacterium abortus* from Milk.

Part IV.

I. FOREST HUDDLESON.

INTRODUCTION.

The rôle which infected udders play in disseminating the abortion bacillus has been studied by a number of investigators. It now becomes apparent to those familiar with infectious abortion, that the control and prevention of this disease will depend largely upon the early diagnosis and bacteriological supervision of temporary or potential carriers. The occurrence and continued presence of *Bact. abortus* in milk coming from apparently normal cows are now established facts, and furnish us a very important carrier problem.

In order to study successfully the occurrence of *Bact. abortus* in milk, the knowledge and application of reliable methods which will permit the isolation of the infecting organism is absolutely necessary, regardless of the number present. The methods employed by previous investigators in studying the presence of *Bact. abortus* in milk have their disadvantages and have not been entirely successful. Fabyan (1) and Schroeder (2) working independently demonstrated the presence of *Bact. abortus* in milk by means of guinea pig inoculation. This method is reliable but has a disadvantage in that it takes from eight to ten weeks for the characteristic lesions to develop, and a large number of guinea pigs is necessary when a number of milk samples is to be studied. Cooledge (3) studied the presence of *Bact. abortus* in milk by means of the agglutination test. This method is not wholly satisfactory owing to the fact that a positive reaction to the agglutination test does not always indicate the presence of the organism. Evans (4) in studying samples of milk from a large number of cows, by employing cultural methods, failed to isolate *Bact. abortus* from the milk of cows which had aborted as a result of natural infection. She succeeded, however, in isolating the organism from the milk of cows which had aborted as a result of feeding and injecting cultures of the organism. This is readily explained from the fact that strains of the organism which have been cultivated upon artificial media may be recovered from inoculated animals without employing anaerobic methods.

EXPERIMENTAL WORK.

In the isolation of *Bact. abortus* from milk the most perplexing difficulty usually encountered is the elimination of other organisms which may be present in considerable numbers thus over-growing the inoculated media.

In order to render the isolation and cultivation of *Bact. abortus* from

milk, a comparatively simple process, the following factors must be considered: The medium and its proper preparation; the proper H-ion concentration of the medium; the employment of an agent which will eliminate fast-growing organisms; the method of incubation.

The proper medium for the isolation and cultivation of *Bact. abortus* is liver or spleen (bovine or swine) infusion agar. This medium was developed by Stafseth (5), formerly of this laboratory. The technique for preparing the medium is similar to the method described by Giltner (6) for the preparation of meat infusion agar except that glass wool should be used in filtering, and excessive heating should be avoided in the preparation and sterilization. Huntoon (7) has shown that about half of the initial growing value of media is removed by over-heating, and employing cotton, cloth, or paper in filtration. The writer has found that the above-named factors must be considered in the isolation and cultivation of *Bact. abortus*.

The H-ion concentration of the medium is the most important factor in the cultivation of this organism. The H-ion concentration for obtaining the optimum growth lies between 6.6 and 6.4. The limiting H-ion concentration in which growth may be obtained lies between 6 and 7.6. The organism grows very slowly at the extreme limits of this range. In fact, it is very difficult to get newly isolated strains to grow on a medium having a different H-ion concentration than the optimum stated above. The H-ion concentrations were in each case determined colorimetrically, using Brom Thymol Blue as indicator. The titratable acidity (using phenophthalein as indicator) for obtaining the optimum growth should be about +1.2. This method, however, is not to be relied upon owing to the fact that a medium giving a titratable reaction of +1.2 may not correspond to the proper H-ion concentration that is necessary for the growth of *Bact. abortus*.

The agent necessary for the partial elimination of other organisms was found to be gentian violet. The selective bactericidal action of gentian violet and its practical application was first studied by Churchman (8). This dye, when incorporated in a medium, will inhibit the growth of a large per cent. of gram positive and a small per cent. of gram negative organisms. Churchman applied the term "violet positive," to those organisms whose growth was inhibited by the action of the dye, and "violet negative" to those which were not affected by the dye. The action of the dye appears to simulate the bactericidal action of various other bactericides in that its action is fundamentally a quantitative one.

In this work, gentian violet was prepared in a saturated aqueous solution and incorporated in the media in sufficient quantity to give the dye a final dilution of 1:10,000. The growth of *Bact. abortus* was not in the least affected by the presence of the dye. The developing colonies take up the color of the dye and present a clear violet blue color to transmitted light and a dark violet color to reflected light. With a little practice, one may easily differentiate colonies of *Bact. abortus* from colonies of other organisms on the media by macroscopic examination alone.

From previous researches there have been developed two satisfactory methods for growing *Bact. abortus* from naturally infected material, namely, in a closed chamber in symbiosis with cultures of *Bacillus sub-*

tilis (9), in a closed chamber which has been partially exhausted of air by means of a suction pump. It is generally believed that the initial growth of this organism depends upon an atmosphere of lowered oxygen tension. If this is true, we should expect newly isolated strains of the organism to grow very rapidly when placed in a sealed tube or chamber in which part of the oxygen has been absorbed by means of an alkaline solution of pyrogallic acid. A series of experiments conducted by the writer shows that the initial growth is not due to a lowered oxygen tension, but is due to an increased carbon dioxide tension of the atmosphere in which it is to be grown. The correct carbon dioxide tension may be derived by sealing the tubes containing the inoculated medium; by placing the inoculated medium in a closed chamber (the growing organisms furnish CO_2 for the proper tension); by placing the inoculated medium in a closed chamber in which 10 per cent. of the air has been displaced by carbon dioxide gas. It was found that when the latter method was employed colonies of *Bact. abortus* would appear on the surface of the medium in from 24 to 72 hours and often develop to 3 mm. in diameter. No visible growth appeared until the fourth day or later when the sealed tube or closed chamber method was used. When the growth became visible it was found that a CO_2 tension had developed in the sealed tube (measured by the H-ion method) which corresponded to the CO_2 tension of a closed chamber after 10 per cent. (by volume) of the contained air had been displaced by CO_2 gas.

The methods which have just been discussed were used in studying samples of milk from each of the four quarters of twelve cows. Cows No. 1, 8, 9, 10, 11, and 12 have never aborted. Cow No. 2 aborted a six months fetus Dec. 18, 1919; Cow No. 3 aborted a five months fetus Oct. 24, 1919; Cow No. 4 aborted a six months fetus Feb. 20, 1919; Cow No. 5 aborted a seven months fetus Feb. 5, 1920; Cow No. 6 aborted a six months fetus Jan. 26, 1920; Cow No. 7 aborted a six months fetus Jan. 1, 1917. The reactions of the milk to the agglutination test at the time the bacteriological examinations were made are shown in Table I.

The samples of milk were collected in sterile test tubes after the first milk had been discarded, and about 10 c. c. of each centrifugalized for two hours at 2000 r.p.m. This length of time for centrifugalizing is necessary owing to the fact that *Bact. abortus* is removed from suspension with difficulty. About 0.1 c. c. of the sediment was drawn from the bottom of the tube by means of a small capillary pipette, then placed on the surface of a solidified gentian violet agar plate and evenly distributed by holding a sterile glass rod (bent at an angle of 90°) against the surface of the medium at the same time rotating the plate in a horizontal plane.

The bacteriological examinations were in each instance controlled by inoculating guinea pigs intra-abdominally with 5.0 c. c. of whole milk from each quarter, and allowing a period of eight to ten weeks to elapse before autopsying. The spleen and liver were then examined culturally for the presence of *Bact. abortus*. The comparative results of the two methods are shown in Table II. The milk from the four quarters of cows No. 1, 5, 7, 8, 9, 10, 11, and 12 gave negative results to each of the methods employed. The positive results correspond in all

of the methods employed: Cow No. 2, showing the organisms present in the left front quarter; No. 3, in the left rear quarter; No. 4, in right front, left rear and left front quarter; No. 5 in the right rear quarter; No. 7 in the left rear quarter.

The number of colonies appearing upon the surface of the media varied with the samples examined. Only one or two colonies would develop from the sample examined from one cow, while from another, the surface of the media would show hundreds of colonies. Very few other organisms present in the milk grew on this medium. Gram negative organisms will occassionally make their appearance and very often be the predominating organism on the surface of the media. These may be, in most part, eliminated by using aseptic methods in the handling of the samples of milk.

This method has also been employed with success in isolating *Bact. abortus* from the stomach content of aborted fetuses, from the fetal membranes and from the uterine exudate of cows which have aborted.

TABLE II.—THE COMPARATIVE RESULTS OF THE TWO METHODS FOR STUDYING THE PRESENCE OF *BACT. ABORTUS* IN MILK.

No. of Cow	Right rear quarter		Right front quarter		Left rear quarter		Left front quarter	
	Guinea pig inoculation	G. V. plate	Guinea pig inoculation	G. V. plate	Guinea pig inoculation	G. V. plate	Guinea pig inoculation	G. V. plate
1	−	−	−	−	−	−	−	−
2	−	−	−	−	−	−	+	+
3	−	−	−	−	+	+	−	−
4	−	−	+	+	+	+	−	−
5		+	−	−	−	−	−	−
6	−	−	−	−	−	−	−	−
7	−	−	−	−	+	+	−	−
8	−	−	−	−	−	−	−	−
9	−	−	−	−	−	−	−	−
10	−	−	−	−	−	−	−	−
11	−	−	−	−	−	−	−	−
12	−	−	−	−	−	−	−	−

The − sign indicates negative findings by guinea pig inoculation or by direct cultural method (gentian violet agar plate).
The + sign indicates the presence of *Bact. abortus* in the spleen and liver of inoculated guinea pigs or by direct cultural method.
G. V., refers to gentian violet agar plate.

TABLE I.—SHOWING THE AGGLUTINATION REACTION OF MILK STUDIED.

No. of Cow	Right Rear Quarter					Right Front Quarter					Left Rear Quarter					Left Front Quarter				
	1-50	1-100	1-200	1-500	1-1000	1-50	1-100	1-200	1-500	1-1000	1-50	1-100	1-200	1-500	1-1000	1-50	1-100	1-200	1-500	1-1000
1	+	+	+	−	−	+	+	−	−	−	+	+	−	−	−	+	p	−	−	−
2	+	p	−	−	−	−	−	−	−	−	+	p	−	−	−	+	+	−	−	−
3	+	+	+	−	−	p	−	−	−	−	+	+	p	−	−	+	p	−	−	−
4	+	+	+	−	−	+	+	+	+	−	+	+	+	+	−	+	+	+	+	−
5	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
6	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
7	+	+	+	−	−	+	−	−	−	−	+	p	−	−	−	+	−	−	−	−
8	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
9	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
10	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
11	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−
12	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−

The + sign indicates complete agglutination.
The p sign indicates partial agglutination.
The − sign indicates the absence of agglutination.

CONCLUSIONS

1. The proper medium for the isolation of *Bact. abortus* from milk is liver infusion agar which has been prepared without excessive heating and filtered through glass wool instead of cotton or paper.
2. The growth of *Bact. abortus* in culture is markedly influenced by the H-ion concentration of the medium. It is important that the medium be adjusted in terms of H-ion concentration.
3. The H-ion concentration necessary for the optimum growth should lie between 6.6 and 6.4.
4. The most suitable method for growing *Bact. abortus* from milk is obtained by placing inoculated media in a closed chamber in which 10 per cent. of the air has been displaced by CO_2 gas.
5. By incorporating a saturated aqueous solution of gentian violet in medium in sufficient quantity to give the dye a final dilution of 1-10,000, a large per cent. of organisms occurring in milk other than *Bact. abortus* may be eliminated. The dye when used in the above dilution has no apparent effect upon the growth of *Bact. abortus.*
6. This technique if carefully followed yields results identical with the guinea pig inoculation method for determining the presence of *Bact. abortus* in milk. Its chief advantage is that it requires only four days to determine the presence of the organism whereas the animal inoculation method requires at least eight weeks.
7. This method may be easily employed in studying a large number of samples of milk, or in detecting the presence of the organism in samples of milk which are often sent to the laboratory for diagnosis.

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RATE AND EXTENT OF SOLUBILITY OF ROCKS AND ROCK-FORMING MINERALS UNDER DIFFERENT TREATMENTS AND CONDITIONS*

Technical Bulletin No. 50.

BY GEORGE J. BOUYOUCOS, SOILS SECTION

HISTORICAL

In a former publication (1) the results of an extensive study on the rate and extent of solubility of soils under different treatments and conditions were presented. Using principally the freezing point method as a means of measuring solubility, it was shown that when different classes of soil were treated with N/10 salt solutions of $Ca(NO_3)_2$, $NaNO_3$, KNO_3, KCl, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, KH_2PO_4, $CaH_4(PO_4)_2$ and $NaC_2H_3O_2$, and then washed free of all soluble salts, and made up to a moisture content of 1 of soil to 0.7 of water and kept at room temperature, the rate of solubility of all the salt treatments, except $(HN_4)_2SO_4$, was slow and gradual and that the process continued for a long time, (120 days), but usually for about 50 days. In the case of $(NH_4)_2SO_4$ the initial velocity was quite rapid but soon slowed down. At the end of about 60 days there was an apparent constancy or equilibrium in the solubility. The extent of solubility at this point was found to be very appreciable in all the salt treatments, and in all the soils, with few exceptions. All the soils except sand, treated with $NaNO_3$, KNO_3, KCl, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, and $NaC_2H_3O_2$ yielded quite a large amount of material to solution, the depression in many cases rising from 0.005 to about 0.110°C or from 125 to 2,750 parts per million of solution. The only salt treatments which did not cause a large solubility product were $Ca(NO_3)_2$, KH_2PO_4 and $CaH_4(PO_4)_2$, the depression in some of these treatments rising only from about 0.007 to 0.015° or from 175 to 355 parts per million. As a general rule $NaNO_3$ and $NaC_2H_3O_2$ in all the soils, except sand, tended to yield the greatest solubility product, $Ca(NO_3)_2$, KH_2PO_4, and $CaH_4(PO_4)_2$ the smallest, and KNO_3, $KClK_2$, SO_4, $(NH_4)_2$ SO_4 and $MgSO_4$ an intermediate product. In many soils $CaH_4(FO_4)_2$, and in a few cases, $Ca(NO_3)_2$ and KH_2PO_4 did not only give the smallest concentration but even a smaller concentration than the check, indicating that these salts have an indifferent or depressing effect upon the solubility of soils. As a whole it appeared that the phosphates tend to depress solubility and that they probably act as conservers of bases under field conditions.

The results of solubility of these singly salt-treated soils were taken to indicate that a salt or fertilizer treatment leaves a residual effect upon the soil, and this residual effect continues to be manifested in increased solubility and in increased crop-producing power. These data also go to indicate

*The writer is very grateful to Mr. Ralph A. Paton for much valuable aid.

that the reaction, between soils and salts seems to be chemical and not physical.

In view of the different residual effects that the different salts or fertilizers have upon the solubility of soils, and in view of many theoretical and practical considerations it was concluded that the solubility factor cannot be considered an absolute or reliable criterion for the state of fertility or crop-producing power of soils. In general, however, it can be said that a very heavily fertilized or extremely rich soil gives a greater solubility product than an unfertilized or poor soil.

Although the solubility attained a constancy at the end of about 60 days, this constancy was not believed to be a true equilibrium, the solution not being saturated when solubility apparently ceases. This seems to be demonstrated by the fact that when different proportions of soil and water are employed an apparent equilibrium is attained in all the ratios, while the solubility product is not at all the same when the equilibrium is reached, and does not become the same no matter how long the soil and water in the different ratios are kept in contact. Furthermore, considering the character of the soil it is deemed extremely doubtful if true equilibrium can ever be attained in the soil solution. The solubility process of the soil would undoubtedly go on for a long time, probably almost indefinitely, in view of the extremely slow rate of solubility, if some factors did not intervene.

When different soils were treated with a combination of salts, including $Ca(NO_3)_2$, $NaNO_3$, KNO_3, KCl, K_2SO_4, $(NH_4)_2SO_4$, $MgSO_4$, KH_2PO_4, $CaH_4(PO_4)_2$ and $NaC_2H_3O_2$, and washed and kept under the same conditions as indicated above, their rate of solubility was also slow, but the extent of solubility was very appreciable. The phosphates in this combination did not depress the solubility very markedly, but when $(NH_4)_2SO_4$ and $NaC_2H_3O_2$ were omitted the decrease became more marked.

Experimental field soils from the Illinois, New York (Cornell), Rhode Island, and Ohio Experiment Stations, which had been fertilized in the usual way were washed and kept at a moisture content of 1 of soil to 0.7 of water and at room temperature. Their rate of solubility was very slow but their extent of solubility varied, being rather appreciable in some of them and quite small in others, and the variation failing to bear any close relation to to the previous fertilizer treatment. These results were in general agreement with those of the single salt treated soils. Even when these soils were kept at an optimum moisture content and placed outdoors under natural conditions, they failed to give a solubility product which bore a close relation to the previous fertilizer treatment, the rate of solubility being very slow and the extent of solubility quite appreciable but far smaller than that of the salt-treated soils.

Soils treated with HNO_3, HCl, H_2SO_4, H_3PO_4, $H_2C_2O_4$, $HC_2H_3O_2$ and $C_6H_8O_7$, washed, maintained at a moisture content of 1 of soil to 0.7 of water and kept at room temperature showed a quiet rapid rate of solubility, although the extent of solubility varied being very small in the case of the inorganic acids, slightly higher with phosphoric acid, and quite appreciable with the organic acids.

In the untreated soils, which were washed, kept at room temperature, and at a moisture content of 1 of soil to 0.7 of water, both the rate and extent of solubility varied considerably between the different soils, there being no close and consistent relationships between the solubility factor and the class of soil, the organic matter content and the fineness of particles. Practically the same results were obtained when an optimum moisture content

was employed and the soils were kept outdoors under natural conditions, although in some soils more material went into solution when the moisture content was 1 of soil to 0.7 of water than when the moisture content was at optimum. There was a closer relationship on the whole between the solubility factor and the state of fertility, or crop producing power of the soil with the former than with the latter.

When natural soils, previously washed, and with a moisture content of 1 of soil to 0.7 of water were kept at a temperature of 53°C their rate of solubility was somewhat appreciably increased. In some soils, however, solubility was very little, if any, affected by the high temperature. The solubility of many soils even at this high temperature continued to increase for a long time, even 60 days but usually became constant at the end of about 30 days.

At the ratio of 1 of soil to 5 of water the rate of solubility of natural soils was also slow and the extent of solubility extremely small, the amount of material that went into solution at this water content being only about half as great as that at the water content of 1 of soil to 0.7 of water, although an apparent equilibrium was attained at this high water content just as with the lower water content. Soils having a ratio of 1 of soil to 5 of water kept at 53°C showed a slight increase in the rate and extent of solubility. The solubility product, however, was only about one-third as great as that of similar soils kept at the same temperature but having a ratio of soil to water of 1 to 0.7, while an apparent equilibrium was attained in the high ratio just as in the small ratio.

The results of experiments wherein were used a ratio of 1 of soil to 5 of water were held to indicate very strongly that the concentration of the soil solution depends upon the relative masses of the soil and water and that the soil does not possess a definite solubility, as definite compounds do. The amount of material that goes into solution seems to increase as the ratio of soil to water is increased up to about the optimum moisture content, and then it decreases.

OBJECT OF PRESENT INVESTIGATION

Since soils are composed of a complex and heterogeneous mass, and the number and variety of factors operating being very great, unknown and uncontrollable, it is extremely difficult, if not impossible, to explain always the results obtained, or to assign them to any particular factor or cause. Many times such experimental results are at best very empirical.

In order, therefore, to obtain more definite, and if possible, more absolute information on the solubility of soils, it was deemed advisable and necessary to repeat the general investigation of the rate and extent of solubility of soils, with rocks and rock forming minerals. It was thought and reasoned that since the rocks and minerals are more definite compounds, or at least to a considerable degree less complex than the soils, their results may be of great value and help in checking up, interpreting and explaining those obtained with soils. Accordingly, the rate and extent of solubility of a large number of rocks and minerals were measured, an attempt being made to include in the list the most common type of soil-forming rocks and minerals.

METHOD EMPLOYED AND MODE OF PROCEDURE

The method employed was the freezing point (2). The general procedure consisted of first grinding the rocks and minerals to fine powder so it could

pass a 100 mesh sieve. The solubility of this powder was then measured in the leached and unleached condition in distilled water, treated with salt solutions and then washed until all the free soluble salts were eliminated, and in the presence of salt solutions. The moisture content in all cases except one was 1 of solid to 0.75 of liquid. The temperature employed was room temperature, a temperature of 53°C, and at a steam pressure of 26 pounds which is equivalent to a temperature of about 117°C. The materials were contained in glass freezing point tubes of high quality. The freezing point depression was determined immediately upon the powder coming in contact with water or salt solution, once every day thereafter for the first four or five days, and at various intervals thereafter for a long period, in some cases for more than 100 days.

Although the solubility of rocks and minerals has been studied from time to time by quite a number of investigators (3) yet strangely to say the subject has not received the complete and comprehensive investigation that it deserves. There is, therefore, much work yet to be done upon the problem and a good deal more to be learned. Furthermore, the rate and extent of solubility of rocks and minerals have never before been studied by the freezing point method, which has proved highly appropriate and unique for this purpose.

LIST OF ROCKS AND MINERALS EMPLOYED

Following is a list of rocks and minerals employed in the study of the rate and extent of their solubility. These rocks and minerals came from three different sources: (1) from the Ward's Natural Science Establishment, Rochester, New York, (2) from the Geological Department of the Michigan Agricultural College, and (3) from a collection gathered by the writer.

LIST OF ROCKS EMPLOYED AND THEIR PREDOMINANT MINERALS

Banded biotite gneiss	quartz, feldspar, mica
Banded granite	hornblend, quartz, feldspar
Biotite granite, 3 varieties	feldspar, quartz, biotite
Compact lithographic limestone	
Crumbled mica-schist	mica, quartz, feldspar
Diabase	plagioclase feldspar, augite
Diorite	plagioclase feldspar, hornblend
Ferrugineous sandstone, 5 varieties	
Hornblend granite	hornblend, quartz, feldspar
Hornblend basalt	hornblend, plagioclase, pyroxene
Hornblend gabbro	hornblend plagioclase, feldspar, labrodorite.
Hydrohlic limestone	
Marble (dolomitic)	
Mica-schist	mica, quartz, feldspar
Pegmatite	feldspar, quartz
Peridotite	olivine, augite
Quartzite, 3 varieties	quartz
Scotch granite	feldspar, hornblend, quartz
Shale, 2 samples	
Siliceous dolomite	
Siliceous sandstone	
Hematite (micaceous)	hornblend, feldspar

LIST OF MINERALS EMPLOYED AND THEIR FORMULAE

Apatite	$(CaF) Ca_4(PO_4)_3$
Amphibole	$(AlFe)_2O_3$, (Mg, Ca, Fe)O, SiO_2
Apophyllite	$H_7KCa_4(SiO_3)_8 + 4\frac{1}{2} H_2O$
Calcite	$CaCO_3$
Chrysolite (olivine)	$(Mg, Fe)_2SiO_4$
Epidote	$Ca_2([Al, FeOH])(Al_2Fe_2 (SiO_4)_3$
Gypsum	$CaSO_4 + 2H_2O$
Syenite, 2 varieties	FeO_3
Kaolinite	$H_4Al_2Si_2O_9$
Limonite	$2Fe_2O_33H_2O$
Oligoclase	$3(NaAlSi_3O_8) + (Ca, Al_2Si_2O_8)$
Orthoclase	$K Al SiO_3 O_8$
Prochlorite	$H_4O(Fe, Mg)_{23}Al_{14}Si_{13}O_{90}$
Pyroxene	Magnesium-iron-calcium-silicate
Quartz (milky var.)	SiO_2
Serpentine	$H_4Mg_3Si_2O_9$
Siderite	$FeCO_3$
Stilbite	$H_4(Na_2Ca) Al_2Si_6O_{18} + 4 H_2O$
Talc	$H_2 Mg_3 Si_4O_{12}$
Zircon	Z_2SiO_4

AMOUNT OF READILY SOLUBLE MATERIAL IN ROCKS AND MINERALS

Before the results on the rate and extent of solubility on long standing are presented, it may be advantageous and of interest to consider first the amount of readily soluble material in the various rocks and minerals investigated. These data are shown in table 1. They were obtained by mixing the powder with definite amounts of distilled water and determining the freezing point depression immediately. Two different moisture contents were employed, low (20%) and high (75%), but since the results at the former moisture content are not complete, only those of the latter are here presented.

TABLE 1

Amount of Readily Soluble Material in Rocks and Minerals at 75 per cent of Moisture. Figures represent freezing point depression.

Name of rocks and mineral	75 per cent moisture C°
Banded biotite gneiss	0.015
Banded granite	.021
Biotite granite	.018
Biotite granite	.020
Biotite granite	.019
Compact lithographic limestone	.018
Crumbled mica-schist	.010
Diabase	.020
Diorite	.020
Ferrugineous sandstone	.050
Ferrugineous sandstone	.057
Ferrugineous sandstone	.045
Ferrugineous sandstone	.010
Ferrugineous sandstone	.010

Name of rocks and mineral	75 per cent moisture C°
Hornblend granite	.020
Hornblend basalt	.020
Hornblend gabbro	.018
Hydrolic limestone	.030
Marble (dolomitic)	.013
Mica-schist	.036
Pegmatite	.025
Peridotite	.042
Quartzite	.020
Quartzite	.022
Quartzite (Baraboo)	.012
Scotch granite	.032
Shale	.050
Shale	.050
Siliceous dolomite	.050
Siliceous sandstone	.030
Syenite	.035
Syenite	.024
Apatite	.022
Amphibole	.015
Apophyllite	.069
Calcite	.012
Chrysolite	.016
Epidote	.016
Gypsum	.044
Hematite	.010
Kaolinite	.011
Limonite	.010
Oligoclase	.020
Orthoclase	.010
Prochlorite	.017
Pyroxene	.030
Quarts	.008
Serpentine	.050
Siderite	.035
Stilbite	.008
Talc	.015
Zircon	.010

The above data show very emphatically and conclusively that there is not only a measurable but also an appreciable amount of material that goes into solution very readily when unleached powder of rocks and rock-forming minerals is brought in contact with distilled water. It will be seen that the freezing point depression varies from 0.008° in quartz to 0.057° in ferruginеous sandstone, to 0.069°C in apophyllite. The majority of the rocks and minerals have a lowering of the freezing point above 0.020°C. These depressions, it must be remembered were obtained when the ratio of powder to water was 1 to 0.75 or at 75 per cent moisture content. At a considerably lower moisture content the freezing point depression of all those rocks and minerals which do not have a definite solubility or do not form a saturated solution immediately, will be considerably greater. Thus, for instance, at

20 per cent moisture content the freezing point depression of the quartz was 0.028°, ferrugineous sandstone 0.145°, apophyllite 0.175°, shale 0.119, apatite 0.059, etc., while at 75 per cent moisture, the depression was 0.008°, 0.057°, 0.069°, 0.050°, and 0.022° respectively. In such materials as calcite, hematite, marble, limonite, etc., the depression at the low moisture content was practically the same as at the high.

If we apply the formula which was established in a mixture of all the minerals and rocks employed that a depression of 0.002°C is equivalent to 100 parts per million of solution then the concentration of the solution of the rocks and minerals varies from 100 p.p.m. in quartz, to 711 in ferrugineous sandstone, to 975 in apophyllite at 75 per cent of moisture content, and 350, 1,811 and 2,187 p.p.m. respectively at 20 per cent of moisture.

It is readily realized, of course, that the solutions of the different rocks and minerals may contain soluble material of different degrees of dissociation which may affect the freezing point depression slightly differently. The above formula, therefore, which was obtained from an average of all the rocks and minerals employed may not be correctly applied to all the different rocks and minerals. It is believed, however, that it gives a very close approximation of the concentration of the solution of these various materials, in parts per million.

The above appreciable amount of readily soluble material in the powder of the different rocks and minerals is obtained, with few exceptions, only with the unleached powder. When the powder is leached with distilled water, the readily soluble material is washed away and very little new material goes into solution to take its place, as indicated by the much smaller freezing point depression. This point is well exemplified by the data in table 2.

TABLE 2

Amount of Soluble Material in Leached and Unleached Powder of Rocks and Minerals. Figures Represent Freezing Point Depression.

Name of Rocks and Minerals	Unleached 75 per cent moisture C°	Leached 75 per cent moisture C°
Banded biotite gneiss	0.015	.006
Banded granite	.021	.011
Biotite granite	.018	.010
Biotite granite	.020	.008
Biotite granite	.019	.010
Compact lithographic limestone	.018	.006
Crumbled mica-schist	.010	.006
Diabase	.020	.008
Diorite	.020	.010
Ferrugineous sandstone	.050	.010
Ferrugineous sandstone	.057	.010
Ferrugineous sandstone	.010	.009
Ferrugineous sandstone	.010	.008
Hornblend granite	.020	.010
Hornblend basalt	.020	.007
Hornblend gabbro	.018	.009
Hydrolic limestone	.030	.015
Marble (dolomitic)	.013	.005

Name of Rocks and Minerals	Unleached 75 per cent moisture C°	Leached 75 per cent moisture C°
Mica-schist	.036	.009
Pegmatite	.025	.010
Peridotite	.042	.021
Quartzite	.020	.009
Quartzite	.022	.008
Quartzite (baraboo)	.012	.003
Scotch granite	.032	.010
Shale	.050	.010
Shale	.050	.010
Siliceous dolomite	.050	.010
Siliceous sandstone	.030	.009
Syenite	.035	.008
Syenite	.024	.008
Apatite	.022	.010
Amphibole	.015	.008
Apophyllite	.069	.027
Calcite	.012	.007
Chryrolite	.016	.006
Epidote	.016	.009
Gypsum	.044	.042
Hematite	.010	.005
Kaolinite	.011	.010
Limonite	.010	.006
Oligoclase	.020	.009
Orthoclase	.010	.008
Prochlorite	.017	.008
Pyroxene	.030	.008
Quartz	.008	.006
Serpentine	.050	.020
Siderite	.035	.015
Stilbite	.008	.005
Talc	.015	.010
Zircon	.010	.007

It will be immediately seen from the above table, therefore, that the freezing point depression, and consequently the amount of material in solution, is appreciably or much smaller after leaching than before leaching, in all the rocks and minerals, with few exceptions.

These results go to show, therefore, that when rocks and minerals are ground very fine they allow a considerable amount of their material to go readily into solution, but when this easily soluble material is leached with few exceptions, its place is not immediately taken by other soluble material.

The reason for these phenomena together with the nature of the material that goes into solution and the mechanism of solubility involved, will be discussed more appropriately and intelligently, subsequently in connection with other phases of the general investigation. Meanwhile it is desired to direct attention to a significant point that is suggested by the foregoing experimental results in regard to the amount of soluble material in the soils, and drift material at the glacial period. One of the works that the great

continental glacier accomplished was the grinding up of the underlying rocks into fine particles. According to the foregoing results land which was formed from this glacial material and which was not excessively leached must have been very rich in soluble material. When this land was enriched with nitrogen, it must have been very productive.

RATE AND EXTENT OF SOLUBILITY OF UNLEACHED AND LEACHED ROCKS AND MINERALS WHEN THE RATIO OF ROCKS AND MINERALS TO DISTILLED WATER WAS 1 to 0.75 and MIXTURE WAS MAINTAINED AT ROOM TEMPERATURE.

The subjoined tables contain the results on the rate and extent of solubility of various rocks and minerals in the unleached and leached state at 75 per cent moisture content and at room temperature. Since there were two series which were conducted at two different times and for a different length of periods, the results of each series are given separately.

TABLE 3.—*Rate and extent of solubility of unleached powdered rocks when the ratio of rocks to distilled water was 1 to 0.75 and the mixture maintained at room temperature. Figures represent freezing point depression.*

Days.	0.	1.	3.	5.	10.	14.	19.	30.	44.	52.	62.	75.	82.	107.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Bandied granite	.020	.027	.028	.025	.026	.030	.030	.027	.030	.028	.030	.030	.029	.028
Biotite granite	.020	.036	.032	.033	.030	.034	.035	.037	.037	.034	.035	.035	.034	.035
Biotite granite	.018	.030	.030	.029	.027	.028	.030	.030	.030	.028	.030	.030	.029	.028
Ferriginous sandstone	.058	.058	.058	.060	.058	.054	.050	.050	.048	.043	.039	.039	.037	.031
Ferruginous sandstone	.059	.050	.053	.051	.034	.035	.035	.037	.035	.033	.034	.034	.034	.032
Hornblend granite	.022	.030	.027	.026	.026	.026	.026	.027	.030	.031	.028	.028	.028	.029
Hydrolic limestone	.035	.036	.037	.032	.027	.028	.030	.030	.030	.028	.026	.026	.025	.025
Mica-schist	.032	.038	.038	.033	.034	.037	.030	.026	.026	.026	.025	.025	.027	.026
Pegmatite	.030	.032	.032	.032	.033	.035	.032	.032	.035	.032	.035	.033	.033	.036
Quartzite	.020	.027	.020	......	......	......	......	......	......	......	......	......	......	......
Quartzite	.020	.022	.027	.025	.025	.028	.035	.035	.035	.034	.033	.034	.035	.034
Scotch granite	.035	.043	.042	.040	.043	.040	.040	.038	.036	.038	.039	.036	.040	.040
Shale	.049	.051	.050	.052	.040	.045	.042	.038	.036	.032	.027	.028	.023	.018
Siliceous sandstone	.030	.033	.030	.032	.025	.027	.030	.025	.026	.026	.026	.025	.025	.025
Syenite	.038	.050	.050	.050	.047	.048	.055	.048	.050	.050	.053	.055	.055	.055

TABLE 4.—*Rate and extent of solubility of leached powdered rocks when the ratio of rocks to distilled water was 1 to 0.75 and mixture maintained at room temperature. Figures represent freezing point depression.*

Days.	0	1	2	4	7	28	35	46	58	66	93
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Banded granite....	.011	.017	.017	.017	.017	.017	.020	.020	.021	.024	.027
Biotite granite.....	.010	.014	.016	.016	.015	.016	.016	.016	.018	.016	.015
Biotite granite.....	.008	.010	.017	.018	.018	.018	.018	.020	.020	.020	.018
Ferruginous sandstone..........	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010
Hornblend granite..	.010	.010	.010	.009	.009	.012	.012	.011	.013	.014	.014
Hydrolic limestone.	.015	.020	.020	.021	.022	.022	.020	.022	.020	.022	.022
Mica-schist........	.009	.010	.011	.012	.014	.012	.012	.012	.010	.013	.013
Pegnatite.........	.010	.010	.015	.014	.015	.014	.015	.015	.014	.015	.017
Quartzite..........	.009	.010	.010	.014	.012	.011	.012	.012	.013	.014	.013
Scotch granite.....	.010	.010	.011	.015	.014	.015	.015	.015	.015	.016	.017
Shale.............	.010	.016	.015	.017	.016	.016	.017	.015	.016	.019	.016
Siliceous sandstone.	.010	.010	.012	.012	.012	.011	.011	.012	.010	.012	.012
Syenite...........	.008	.011	.017	.020	.018	.020	.025	.023	.024	.036	.035

TABLE 5.—*Rate and extent of solubility of unleached powdered minerals when the ratio of minerals to distilled water was 1 to 0.75 and the mixture maintained at room temperature. Figures represent freezing point depression.*

Days.	0.	1.	2.	4.	8.	12.	22.	30.	54.	68.	80.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Apatite..........	.022	.023	.022	.021	.020	.020	.022	.021	.020	.022	.020
Amphibole........	.015	.021	.020	.022	.022	.023	.025	.025	.024	.026	.029
Apophyllite.......	.069	.076	.075	.077	.076	.077	.083	.080	.080	.082	.083
Calcite...........	.012	.010	.010	.010	.010	.011	.010	.010	.010	.011	.010
Chrysolite (olivine).	.016	.014	.014	.015	.015	.014	.015	.014	.015	.014	.016
Epidote...........	.016	.016	.015	.014	.017	.018	.016	.016	.016	.016	.018
Gypsum..........	.041	.043	.044	.045	.043	.043	.048	.043	.040	.040	.050
Hematite (micaceous)	.012	.010	.010	.007	.006	.010	.007	.008	.008	.010	.008
Kaolinite.........	.011	.015	.016	.015	.016	.016	.015	.016	.015	.016	.015
Limonite..........	.010	.010	.011	.009	.008	.006	.008	.007	.009	.008	.008
Oligoclase.........	.020	.017	.020	.020	.023	.023	.023	.021	.027	.022	.029
Orthoclase........	.010	.013	.012	.011	.012	.013	.017	.020	.020	.020	.020
Prochlorite........	.017	.016	.015	.015	.015	.016	.015	.015	.013	.014	.014
Pyroxene..........	.030	.028	.025	.025	.030	.023	.025	.027	.025	.025	.028
Quartz............	.008	.011	.011	.006	.009	.008	.009	.009	.006	.008	.008
Serpentine........	.050	.043	.041	.038	.038	.037	.027	.030	.026	.024	.025
Siderite..........	.035	.040	.040	.040	.040	.039	.037	.036	.037	.038	.040
Stilbite...........	.008	.010	.011	.010	.011	.007	.010	.010	.011	.010	.010
Talc.............	.015	.014	.016	.015	.015	.017	.014	.016	.015	.014	.020
Zircon...........	.010	.010	.010	.010	.001	.010	.013	.009	.010	.010	.010

TABLE 6.—*Rate and extent of solubility of unleached powdered rocks when the ratio of rocks to distilled water was 1 to 0.75 and mixture maintained at room temperature. Figures represent freezing point depression.*

Days.	0.	1.	2.	4.	8.	12.	22.	30.	54.	68.	80.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°
Banded biotite-gneiss	.015	.015	.012	.013	.023	.015	.023	.020	.020	.021	.024
Biotite granite	.016	.017	.020	.016	.017	.018	.024	.020	.020	.022	.027
Compact lithographic limestone	.018	.018	.016	.014	.018	.017	.017	.017	.017	.018	.021
Crumbled mica-schist	.010	.012	.012	.012	.010	.010	.011	.015	.015	.018	.017
Diabase	.020	.018	.020	.020	.019	.020	.020	.020	.020	.021	.020
Diorite	.020	.017	.020	.020	.019	.020	.019	.020	.020	.019	.025
Hornblend basalt	.020	.023	.020	.022	.023	.020	.020	.022	.022	.023	.027
Horblend gabbro	.018	.020	.021	.019	.019	.021	.021	.021	.022	.020	.020
Marble (dolomitic)	.013	.013	.014	.013	.012	.015	.019	.017	.026	.026	.028
Peridotite	.042	.043	.042	.040	.040	.040	.042	.040	.047	.050	.055
Quartzite (baraboo)	.012	.012	.010	.012	.012	.011	.011	.012	.011	.012	.012
Red roofing slate	.021	.020	.019	.019	.019	.020	.020	.019	.032	.034	.036
Siliceous dolomite	.050	.047	.045	.045	.046	.048	.048	.050	.045	.045	.050
Shale	.050	.050	.048	.046	.042	.044	.044	.041	.041	.040	.038
Syenite	.024	.022	.022	.020	.020	.020	.020	.024	.024	.023	.025

TABLE 7.—*Rate and extent of solubility of leached powdered minerals when the ratio of minerals to distilled water was about 1 to 0.75 and mixture maintained at room temperature. Figures represent freezing point depression.*

Days.	0.	1.	3.	7.	14.	31.	50.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Apatite	.010	.010	.010	.012	.010	.010	.013
Amphibole	.008	.008	.010	.011	.010	.010	.010
Apophyllite	.027	.034	.033	.034	.035	.035	.035
Calcite	.007	.008	.008	.007	.008	.008	.009
Chrysolite	.006	.008	.010	.010	.010	.010	.009
Epidote	.009	.006	.008	.010	.010	.010	.010
Gypsum	.040	.042	.043	.042	.040	.041	.045
Hematite (micaceous)	.005	.006	.006	.006	.009	.008	.007
Kaolinite	.010	.009	.009	.009	.010	.010	.008
Limonite	.006	.006	.008	.008	.009	.010	.009
Oligoclase	.009	.009	.009	.010	.010	.012	.011
Orthoclase	.008	.006	.008	.008	.010	.008	.010
Prochlorite	.008	.010	.010	.010	.011	.010	.010
Pyroxene	.008	.009	.006	.008	.009	.010	.010
Quartz	.006	.007	.008	.007	.007	.006	.009
Serpentine	.020	.024	.018	.014	.012	.010	.011
Siderite	.015	.022	.024	.026	.025	.024	.028
Stilbite	.005	.005	.005	.008	.007	.007	.009
Talc	.010	.010	.014	.013	.012	.012	.014
Zircon	.007	.006	.006	.006	.006	.007	.008

TABLE 8.—*Rate and extent of solubility of leached powdered rocks when the ratio of rock to distilled water was about 1 to 0.75 and mixture maintained at room temperature. Figures represent freezing point depression.*

Days.	0.	1.	3.	7.	14.	31.	50.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Banded biolite-gneiss	.009	.008	.006	.009	.010	.008	.011
Biotite granite	.006	.008	.010	.009	.008	.012	.012
Compact lithographic limestone	.006	.005	.005	.008	.009	.008	.008
Crumbled mica-schist	.006	.005	.006	.008	.009	.009	.008
Diabase	.008	.008	.011	.011	.012	.010	.012
Diorite	.010	.010	.010	.010	.010	.009	.011
Hornblend basalt	.009	.008	.009	.010	.010	.010	.010
Hornblend gabbro	.009	.006	.006	.010	.010	.009	.011
Marble (dolomitic)	.005	.009	.008	.010	.010	.010	.011
Peridotite	.021	.022	.020	.019	.021	.022	.025
Quartzite (baraboo)	.003	.003	.004	.003	.005	.003	.007
Red roofing slate	.008	.009	.010	.014	.012	.013	.015
Siliceous dolomite	.010	.010	.012	.010	.010	.010	.010
Shale	.016	.018	.014	.016	.014	.015	.015
Syenite	.009	.008	.011	.014	.013	.016	.019

Considering first tables 3, 5 and 6 which contain the rate and extent of solubility of the unleached rocks and minerals, it is at once seen that there is very little, if any, additional material that went into solution after the first contact with water. Although the mixtures were allowed to remain for 107 days in one series, yet the freezing point depression hardly increased more than 0.015°C, and in the majority of the samples the increase is less than 0.010°C. In fact in a few rocks and minerals the initial depression has decreased instead of increased. Thus, in shale for instance, the depression has decreased from 0.049° to 0.018°, in one of the ferruginous sandstones from 0.059° to 0.032° and in serpentine from 0.050° to 0.025°.

Considering next tables 4, 7 and 8 which contain the data for the leached rocks and minerals it will be readily observed here also that very little, if any, additional material has gone into solution above the initial amount. The increase is only about 0.010° or less, in about 50 or 107 days. With few exceptions the leached rocks and minerals do not attain the same degree of freezing point depression, or concentration of solution, as existed before leaching, at about the same moisture content.

From this phase of the general investigation, therefore, three main conclusions may be drawn: (1) At room temperature the rate and extent of solubility of rocks and minerals both in the leached and unleached condition are very small after the initial solubility. (2) There seems to be an equilibrium attained in solubility. This equilibrium, however, as will be shown subsequently, is only apparent and not real, with few exceptions. (3) In few of the rocks and minerals there is a tendency of the initial material in solution to go out of solution, or at least the freezing point depression decreases. This is especially true when the rocks and minerals are unleached.

RATE AND EXTENT OF SOLUBILITY OF UNLEACHED AND LEACHED ROCKS AND MINERALS WHEN THE RATIO OF ROCKS AND MINERALS TO DISTILLED WATER WAS 1 to 0.75 AND THE MIXTURE WAS MAINTAINED AT A TEMPERATURE OF 53°C.

In the tables below are presented the results on the rate and extent of solubility of unleached and leached rocks and minerals when the ratio of rocks and minerals to distilled water was 1 to 0.75 and the mixture was maintained at the temperature of 53°C. The samples of these rocks and minerals were of the same original material and prepared exactly the same as those at room temperature. The moisture content also was the same. The results of each series are presented separately.

TABLE 9.—*Rate and extent of solubility of unleached powdered rocks when the ratio of rocks to distilled water was 1 to 0.75 and the mixture maintained at the temperature of 53° C. Figures represent freezing point depressions.*

Days.	0.	1.	3.	5.	10.	12.	17.	27.	32.	34.	51.	61.	69.	79.	83.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Banded granite	.021	.034	.038	.040	.043	.042	.042	.050	.055	.060	.058	.059	.060	.060	.063
Biotite granite	.020	.038	.045	.038	.040	.045	.041	.047	.060	.057	.058	.065	.072	.069	.075
Biotite granite	.019	.030	.042	.035	.037	.038	.037	.043	.050	.045	.053	.060	.078	.075	.083
Ferruginous sandstone	.050	.060	.062	.055	.052	.050	.044	.045	.050	.042	.045	.040	.045	.047	.042
Ferruginous sandstone	.057	.062	.057	.058	.055	.052	.052	.055	.056	.057	.060	.070	.070	.073	.072
Hornblend	.020	.022	.032	.026	.030	.032	.032	.037	.050	.047	.045	.058	.060	.060	.064
Hydrolic limestone	.030	.038	.038	.033	.035	.039	.040	.048	.055	.060	.065	.075	.097	.100	.100
Mica-schist	.036	.040	.040	.010	.037	.047	.042	.050	.055	.055	.060	.060	.070	.070	.071
Pegmatite	.025	.038	.040	.046	.044	.052	.053	.059	.070	.078	.086	.091	.120	.117	.137
Quartzite	.020	.026	.033	.025	.025	.040	.043	.065	.080	.093	.098	.105	.120	.130	.132
Quartzite	.022	.033	.033	.035	.037	.040	.042	.052	.065	.077	.085	.085	.095	.094	.113
Scotch granite	.032	.042	.048	.045	.042	.055	.050	.063	.070	.080	.084	.088	.092	.094	.091
Shale	.050	.065	.060	.050	.040	.050	.045	.046	.045	.041	.043	.040	.043	.044	.045
Siliceous sandstone	.030	.040	.040	.035	.038	.038	.036	.040	.040	.040	.045	.052	.055	.054	.058
Syenite	.035	.052	.061	.060	.057	.060	.066	.075	.085	.082	.085	.099	.109	.103	.119

TABLE 10.—*Rate and extent of solubility of leached powdered rocks when the ratio of rocks to distilled water was 1 to 0.75 and the mixture maintained at the temperature of 53° C. Figures represent freezing point depression.*

Days.	0.	1.	2.	4.	9.	11.	16.	29.	34.	45.	53.	63.	67.	74.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Banded granite	.010	.016	.018	.017	.023	.025	.030	.030	.041	.040	.055	.060	.058	.059
Biotite granite	.010	.017	.017	.017	.024	.028	.025	.025	.041	.047	.051	.074	.075	.076
Biotite granite	.010	.015	.015	.020	.026	.025	.025	.040	.052	.060	.070	.067	.070	.070
Ferruginous sandstone	.010	.012	.015	.018	.019	.018	.020	.018	.018	.019	.025	.028	.029	.028
Ferriginous sandstone	.010	.020	.018	.018	.019	.016	.020	.020	.018	.020	.020	.038	.043	.041
Hornblend	.010	.010	.010	.014	.017	.025	.025	.025	.027	.027	.032	.049	.050	.051
Hydrolic limestone	.015	.019	.025	.027	.025	.025	.027	.030	.040	.043	.052	.062	.060	.060
Scotch granite	.010	.015	.020	.025	.030	.030	.030	.037	.043	.048	.049	.059	.065	.065
Shale	.010	.020	.025	.030	.029	.028	.026	.025	.028	.026	.026	.025	.028	.028
Siliceous sandstone	.010	.012	.012	.013	.013	.015	.016	.021	.035	.040	.040	.043	.045	.046

TABLE 11.—*Rate and extent of solubility of leached powdered minerals when the ratio of minerals to distilled water was about 1 to 0.75 and the mixture maintained at a temperature of 53°C. Figures represent freezing point depression.*

Days.	0.	3.	11.	21.	37.	50.	65.	95.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Apatite	.008	.010	.008	.018	.031	.036	.052	.007
Amphibole	.010	.018	.022	.026	.056	.063	.100	.124
Apophyllite	.027	.039	.034	.036	.050	.050	.056	.055
Calcite	.007	.009	.010	.018	.035	.037	.050	.060
Chrysolite	.005	.024	.046	.045	.110	.140	.160	.220
Gypsum	.040	.040	.043	.044	.052	.055	.058	.069
Hematite (micaceous)	.005	.008	.002	......	......	......	......	......
Kaolinite	.008	.010	.014	.014	.013	.013	.013	.014
Limonite	.005	.022	.020	.025	.030	.033	.044	.045
Oligoclase	.007	.020	.027	.033	.048	.058	.068	.114
Orthoclase	.005	.010	.020	.020	.022	.023	.050	.073
Prochlorite	.008	.010	.008	.011	.011	.010	.031	.030
Pyroxene	.005	.005	.005	.010	.015	.018	.030	.050
Quartz	.007	.010	.010	.016	.123	.153	.202	.357
Serpentine	.020	.019	.040	.054	.110	.198	.265	.340
Siderite	.015	.030	.026	.036	.060	.080	.100	......
Stilbite	.005	.001	.008	.008	.020	.038	.038	.038
Talc	.010	.015	.012	.023	.034	.040	.049	.048

TABLE 12.—*Rate and extent of solubility of leached powdered rocks when the ratio of rocks to water was about 1 to 0.75 and mixture maintained at the temperature of 53°C. Figures represent freezing point depression.*

Days.	0.	3.	11.	21.	37.	50.	65.	95.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Banded biotite-gneiss	.008	.014	.014	.015	......	......	......	......
Biotite granite	.005	.015	.011	......	......	......	......	......
Compact lithographic limestone	.006	.014	.015	.015	.030	.040	.063	.060
Crumbled mica-schist	.005	.006	.006	.005	.022	.032	.032	.048
Diabase	.005	.010	.020	.020	.048	.048	.054	.069
Diorite	.010	.011	.012	.016	.031	.031	.039	.047
Hornbled gabbro	.008	.010	.010	.016	.026	.028	.052	.082
Marble (dolomitic)	.008	.010	.010	.017	.053	.053	.069	.071
Peridotite	.020	.020	.020	.033	.059	......	......	......
Quartzite (baraboo)	.003	.014	.021	.047	.116	.123	.152	.278
Red roofing slate	.009	.020	.018	.018	.027	.029	.034	.034
Siliceous dolomite	.010	.020	.017	.033	.050	.061	......	......

From an examination of the above data it becomes at once evident that the temperature of 53°C had a very marked influence both on the rate and extent of solubility of all the rocks and minerals, both leached and unleached, with few exceptions. With the exception of shale, and kaolimite the rate of solubility was considerably hastened and the extent greatly increased in all of the rocks and minerals. In some of the rocks and minerals the amount of material that went into solution at the end of 83 or 95 days is really tremendous. Thus, in the unleached condition the depression of one of the biotite granites rose from .019° to .083°, in pegmatite from .025° to .137°, in quartzite from .020 to .132°, in siliceous sandstone from .030° to .058°. In the leached condition the depression rose in amphibole from .010° to 0.124°, in chrysolite from 0.005° to 0.220°, in quartz from 0.007 to 0.357°, in serpentine from 0.020° to 0.340° etc. Expressing these depressions in parts per million of solution, the amount of material that disolved was as high as 1650 p.p.m. in some of the unleached rocks and as high as 4962 p.p.m. in some of the leached minerals.

Of all these results the most surprising and unexpected are those yielded by the quartz and the quartzites. These materials gave the highest solubility obtained with one or two exceptions. The quartz gave a solubility of 0.357° and the baraboo quartzite 0.278° at the end of 95 days, and two other quartzites 0.113° and 0.132° respectively at the end of 83 days. When it is considered that these materials are supposed to be composed almost entirely of silica, which is believed to be very insoluble, their tremendous solubility is certainly most surprising and unexpected. Of course, these materials were impure, as indicated both by their rather darkish color when finely ground, and by their alkaline reaction to phenolphthalein, but it is hardly believeable that they contained more bases than some of the other rocks and minerals which gave a considerably smaller solubility product. Indeed analyses showed that this solubility product consisted almost entirely of soluble silica which after the solution became supersaturated with it, was precipitated as hydrated silica. Another interesting point about these siliceous materials is that their rate of solubility is highest not at the beginning but after a long time. It seems as though after a certain length of time in contact with water and at the high temperature, they underwent decomposition and allowed material to go into solution more rapidly.

The high temperature did not increase the solubility of kaolinite and shale and one of the ferrugineous sandstones. The initial depression of the freezing point of the shale and of one of the ferrugineous sandstones not only did increase at the high temperature but actually decreased. Thus, the depression of the shale decreased from 0.65° at the second day to 0.045° at the end of 83 days, while that of the ferrugineous sandstone diminished from 0.062° the third day to 0.042° at the end of 83 days. The shale, behaved, as it will be recalled, similarly even at the room temperature.

Although at room temperature the solubility of nearly all the rocks and minerals becomes stationary from the beginning, at the temperature of 53°C it continues to go on even at the end of 95 days, without any apparent signs of stopping, and in some cases it progresses with an increased velocity. These results go to emphasize two important facts: (1) that the solubility of all the rocks and minerals, with few exceptions, is so slow after the initial solubility that at room temperature it is hardly perceptible, and (2) that a higher temperature tends to decompose or hydrolize them slowly but perceptibly.

Another very interesting point that is revealed by the solubility results

at the high temperature is that even though the rocks and minerals are cooled to two or three degrees below zero centigrade the solubility product still remains high, indicating that they have not yet reached equilibrium or the saturation point at the temperature of 53°C.

EFFECT OF HIGH TEMPERATURE UNDER PRESSURE OF THE SOLUBILITY OF LEACHED ROCKS AND MINERALS.

Since the foregoing study showed very conclusively that a temperature of about 53°C had a very marked increasing effect on the solubility of nearly all the rocks and minerals, a desire arose to investigate the influence on solubility of a greatly higher temperature but at a shorter period. Accordingly, into a second series of freezing point tubes were placed equal amounts of leached powder of rocks and minerals and distilled water as were employed in the previous temperature series, and each tube carefully weighed. All the tubes then were set in an autoclave and heated for 8 hours at about 26 pounds steam pressure. This steam pressure is equivalent to a temperature of 117°C. The tubes were then taken out after cooled, brought back to the original weight by the addition of distilled water, and the freezing point depression of their contents determined. In table 13 and 14 are presented the data obtained. For convenient and immediate comparison the depression before heating and that at the temperature of 53°C are given in the same tables.

TABLE 13.—*Effect of heating under pressure on the solubility of leached powdered minerals when the ratio of minerals to distilled water was about 1 to 0.75 and mixture maintained under a pressure of about 26 pounds for about 8 hours. Figures represent freezing point depression.*

	Before heating.	Heated under pressure for 8 hours.	At 53° temperature for 95 days.
	C°.	C°.	C°.
Apatite	.010	.042	.077
Amphibole	.018	.032	.124
Apophyllite	.027	.054	.055
Calcite	.007	.043	.060
Epidote	.009	.021	....
Gypsum	.040	.050	.069
Hematite (micaceous)	.005	.070	....
Kaolinite	.010	.010	.014
Limonite	.006	.019	.045
Oligoclase	.009	.039	.114
Orthoclase	.008	.028	.073
Prochlorite	.008	.020	.030
Serpentine	.020	.115	.340
Siderite	.015	.053	....
Stilbite	.005	.017	.038
Talc	.010	.030	.048
Zircon	.007	.017	....

TABLE 14.—*Effect of heating under pressure on the solubility of powdered rocks when the ratio of rocks to distilled water was about 1 to 0.75 and mixture maintained under a pressure of about 26 pounds for about 8 hours. Figures represent freezing point depression.*

	Before heating.	Heated under pressure for 8 hours.	at 53° C temperature for 95 days.
	C°.	C°.	C°.
Biotite granite	.006	.022	....
Compact lithographic limestone	.006	.038	.060
Crumbled mica schist	.006	.015	.048
Diorite	.010	.015	.047
Hornblend gabbro	.009	.029	.082
Marble (dolomitic)	.005	.074	.071
Peridotite	.021	.047	*
Red roofing slate	.008	.027	.034
Siliceous dolomite	.010	.056	*
Shale	.016	.020	*
Syenite	.009	.025	*
Quartzite (baraboo)	.003	.070	.278

*Tubes broke.

A comparison between the first two columns to the left in the above tables reveals at once the fact that heating the rocks and minerals under a steam pressure of 26 pounds, which is equivalent to a temperature of 117°C, for 8 hours, markedly increased their solubility product, and this increase was greater in some rocks and minerals than in others. The increase varies from 0 in kaolinite to 0.032° in apatite, to 0.069 in marble to 0.095 in serpentine. By comparing the last two columns to the right, however, it is immediately seen that the increase of solubility under the steam pressure was not anywhere as great, especially in some rocks and minerals, as that at the temperature of 53°C at the end of 95 days. Under steam pressure, for instance, the depression of the amphibole was only 0.032,° and serpentine 0.115°C, while at the temperature of 53°C at the end of 95 days it was 0.124° and 0.340°C respectively. Evidently, therefore, the steam pressure of 26 pounds for 8 hours did not produce the same amount of solubility as the temperature of 53°C for 95 days.

Under steam pressure the solubility was affected not only by the temperature but probably also by pressure. To what extent the latter influences it cannot be stated.

RATE AND EXTENT OF SOLUBILITY OF UNLEACHED ROCKS AND MINERALS WHEN THE RATIO OF SOLID TO LIQUID WAS 1 TO 5, AND MIXTURE MAINTAINED AT ROOM TEMPERATURE AND ALSO AT A TEMPERATURE OF 53°C.

Definite compounds, at any given temperature have a definite solubility which is independent of the relative masses of solid and liquid. In the case of soils it was found that their solubility product depended upon the relative masses of solid liquid. In order to ascertain more definitely than is indicated by the foregoing results, if the solubility of minerals and rocks is also independent of the relative masses of solid and liquid a series of experiments were performed. The procedure consisted of adding 25 cc of distilled water

to 5 grams of unleached minerals and rocks and determining the freezing point depression of the mixture immediately and at various intervals for a prolonged period. Two different temperatures were employed in this series of experiments: room temperature and a temperature of 53°C. The results obtained are shown in the tables 15 and 16.

TABLE 15.—*Rate and extent of solubility of unleached minerals and rocks when the ratio of solid to liquid was 1 to 5 and mixtures maintained at room temperature. Figures represent freezing point depression.*

Days.	0.	3.	6.	13.	22.	30.
	C°.	C°.	C°.	C°.	C°.	C°.
Apatite	.007	.007	.006	.008	.010	.010
Amphibole	.007	.007	.007	.008	.009	.011
Apophyllite	.025	.032	.038	.040	.040	.038
Calcite	.005	.010	.011	.012	.013	.013
Chrysolote	.007	.008	.008	.009	.010	.010
Gypsum	.035	.045	.042	.042	.045	.045
Hematite	.003	.003	.004	.005	.005	.006
Kaolinite	.004	.004	.003	.004	.005	.006
Limonite	.007	.007	.007	.008	.008	.008
Oligocase	.008	.008	.009	.009	.010	.010
Orthoclase	.007	.008	.010	.010	.011	.012
Prochlorite	.003	.004	.005	.008	.008	.010
Pyroxene	.009	.009	.010	.010	.013	.014
Quartz	.004	.004	.005	.005	.005	.005
Serpentine	.013	.015	.016	.018	.018	.018
Siderite	.011	.020	.020	.020	.020	.020
Stillbite	.005	.005	.006	.008	.009	.009
Talc	.005	.006	.006	.008	.009	.010
Zircon	.003	.004	.004	.005	.006	.006
Banded biotite granite	.008	.008	.008	.009	.010	.010
Biotite granite	.012	.012	.013	.013	.014	.016
Compact lithographic limestone	.006	.009	.010	.012	.015	.015
Crumbled mica-schist	.003	.003	.004	.005	.005	.008
Diabase	.007	.007	.008	.008	.010	.010
Diorite	.005	.006	.008	.008	.009	.009
Hornblend basalt	.004	.005	.005	.006	.008	.008
Hornblend gabbro	.005	.006	.006	.007	.007	.010
Marble (dolomitic)	.004	.005	.005	.005	.006	.006
Peridotite	.005	.010	.012	.015	.018	.019
Quartzite (baraboo)	.006	.006	.007	.007	.007	.007
Red roofing slate	.005	.006	.007	.008	.009	.009
Siliceous dolomite	.012	.012	.013	.014	.015	.015
Shale	.009	.009	.010	.010	.011	.015
Syenite	.005	.005	.007	.008	.010	.010

TABLE 16.—*Rate and extent of solubility of unleached minerals and rocks when the ratio of solid to liquid was 1 to 5 and mixture maintained at a temperature of 53°C.*

Days.	0.	3.	6.	25.	32,	37,	90.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.
Apatite	......	......	......	......	......	......	......
Amphibole	.008	.010	.010	.020	.020	.022	.034
Apophyllite	.027	.034	.035	.050	.051	.052	.060
Calcite	.005	.010	.014	.020	.020	.020	.031
Chrysolite	.005	.008	.010	.018	.025	.027	.052
Gypsum	.035	.041	.040	.045	.046	.046	.061
Hematite	.004	.005	.005	.020	.022	.023	.046
Kaolinite	.005	.006	.008	.010	.013	.015	.024
Oligoclase	.008	.009	.011	.018	.020	.021	.040
Prochlorite	.003	.010	.013	.015	.015	.015	.045
Pyroxene	.009	.014	.015	.016	.017	.020	.039
Quartz	.005	.006	.010	.040	.050	.051	.085
Serpentine	.010	.011	.011	.023	.045	.046	.085
Siderite	.012	.025	.025	.025	.027	.035	.062
Stilbite	.006	.006	.010	.012	.017	.018	.029
Talc	.005	.006	.007	.012	.024	.026	.100
Zircon	.004	.005	.006	.017	.017	.018	.022
Banded biotite granite	.008	.010	.015	.023	.023	.023	.044
Biotite granite	.010	.011	.013	.016	.020	.020	.055
Compact lithographic limestone	.007	.010	.012	.012	.014	.019	.039
Crumbled mica-schist	.003	.004	.005	.007	.010	.010	.027
Diavese	.007	.010	.010	.013	.016	.018	.043
Diorite	.006	.010	.010	.022	.027	.027	.045
Hornblend basalt	.004	.008	.010	.017	.019	.019	.040
Marble (dolomitic)	.005	.006	.010	.020	.020	.021	.035
Peridotite	.006	.006	.010	.027	.026	.028	.049
Quartzite (baraboo)	.006	.010	.010	.021	.023	.024	.065
Red roofing slate	.006	.014	.021	.025	......	......	......
Shale	.009	.010	.012	.016	.020	.023	.045
Syenite	.005	.008	.012	.014	.020	.021	.075

Considering first, table 15 which contains the data obtained at room temperature and comparing it with the corresponding tables 5 and 6 it will be readily seen that with few exceptions the solubility in all the rocks and minerals is much smaller at the ratio of 1 of solid to 5 of liquid than it is at the ratio of 1 of solid to 0.75 of liquid. Indeed, in the majority of minerals and rocks the magnitite is only one-half or one-third as large at the ratio of 1 to 5 as it is at the ratio of 1 to 0.75. In some of the minerals, however, such as the calcite, gypsum, hematite, limonite, etc., the solubility product at corresponding dates is about the same at both ratios.

These results, therefore, are very much the same as those obtained with

soils under the same conditions, and would go to indicate that the minerals and rocks employed do not seem to have a definite solubility, with few exceptions. If they do, their rate of solubility is so extremely slow at ordinary temperatures that they may never attain complete equilibrium.

Considering next table 16 which contains the results obtained at the temperature of 53°C it becomes at once apparent that even at the high ratio of liquid to solid the elevated temperature had a very pronounced influence on the solubility product on all of the minerals and rocks with few exceptions. By comparing these results with those in tables 11 and 12 it is readily seen that the solubility product at the ratio of 1 to 5 is about as great as that at the ratio of 1 to 0.75, at the corresponding dates. Evidently, therefore, at the elevated temperature, the solubility product of the minerals and rocks is not so dependent on the relative masses of solid to liquid, as it is at lower temperature. This fact, however, does not mean that the various minerals and rocks have a definite solubility.

DISCUSSION OF RESULTS

The experimental results thus far presented have shown the following main facts:

(1) That the amount of readily soluble material in the unleached powder of rocks and minerals is quite appreciable, especially in some rocks and minerals.

(2) At room temperature the quantity of additional solubility after the initial solubility both in the unleached and leached rocks and minerals is extremely small, even for a period of over one hundred days.

(3) At the temperature of 53°C and also at the steam pressure of 26 pounds, the solubility of nearly all the rocks and minerals employed was considerably increased, and in some rocks and minerals greatly more than in others.

(4) At room temperature the solubility of rocks and minerals was much smaller at the ratio 1 of solid to 5 of liquid than at the ratio of 1 to 0.75. At the temperature of 53°C, however, it was about the same at both ratios for the same date.

(5) The solution of all the rocks and minerals employed reacted alkaline.

From these experimental facts two outstanding conclusions are very apparent, namely (1) that the rocks and minerals employed, with few exceptions, do not show a definite solubility as definite chemical compounds do; and (2) the equilibrium attained in solubility at the various moisture contents and temperatures is only apparent and not real or absolute.

A consideration of the nature and composition of the rocks and rock forming minerals together with the type of their reaction with water, makes the above experimental facts and conclusions appear reasonable and logical.

The minerals which go to make the rocks are largely salts of a strong base or bases: sodium, potassium, calcium, magnesium, ferrous, iron, manganese, etc., combined with a weak inorganic acid: silicic, aluminic, alumino-silicic, ferro-silicic, etc. It logically follows, therefore, that water not only dissolves them but also hydrates them and hydrolyzes them. Their alkaline reaction is a strong proof that they are hydrolyzed. On account of their complex composition, relatively difficult solubility, and their tendency to hydrate and to hydrolyze with water, probably they should not be expected to give a definite solubility or a true condition of chemical equilibrium.

The marked increase in soluble content at the higher temperature is undoubtedly wholly the result of hydrolysis. The high temperature helped the minerals and rocks to decompose and hydrolyze more rapidly.

The material which went into solution was not analyzed and consequently no discussions will be presented here regarding its composition. This paper will be restricted only to the presentation of the results and to those discussions warranted by the results. The chemical composition of the solubility product of the rocks and minerals together with the germain discussions and theories will form, it is hoped, the subject matter of a later paper.

Finally it should be stated that the marked increase in solubility of the rocks and minerals at the higher temperatures throws a new light and furnishes a good proof that the large increase in solubility obtained in soils at similar high temperatures, in the previous investigation, was not due wholly to the decomposition of the organic matter content but also to the solubility and hydrolysis of the mineral particles of the soils.

RATE AND EXTENT OF SOLUBILITY OF ROCKS AND MINERALS TREATED WITH SINGLE SALT SOLUTIONS AND THEN WASHED UNTIL ALL THEIR FREE SOLUBLE SALTS WERE ELIMINATED. RATIO OF SOLID TO DISTILLED WATER WAS 1 TO 0.75 AND MIXTURES MAINTAINED AT ROOM TEMPERATURE.

In treating soils with salt solutions, then washing them until all the free soluble salts were eliminated and then studying their solubility, it was found that some of the salts greatly increased the rate and extent of solubility of all the different classes of soil except sand, while other salts had very little or no effect upon the solubility.

Since these results are of considerable theoretical as well as practical interest and importance, it was deemed advisable to repeat the investigation also with rocks and minerals. The procedure consisted of mixing about 50 grams of powder of rocks or minerals with 250 cc. of N/10 solution of $Ca(NO_3)_2$, $NaNO_3$, KNO_3, KCl, $(NH_4)_2SO_4$, $NaCl$, K_2SO_4, $CaH_4(PO_4)_2$, KH_2PO_4, and $NaC_2H_3O_2$, allowing the mixtures to stand for about 24 hours at room temperature and occasionally stirring and then leaching the solid material with distilled water until entirely free from soluble salts. The washed powder was then placed in tubes with a water content of about 1 of solid to 0.75 of water and its freezing point depression determined in the usual manner. Table 17, 18 and 19 represent typical results obtained.

TABLE 17.—*Rate and extent of solubility of powdered biotite granite which was first treated with salt solutions and then washed until all soluble salts were eliminated. Ratio of powdered rock to distillled water was about 1 to 0.75 and mixture maintained at room temperature. Figures represent freezing point depression.*

Days.	0.	1.	2.	3.	5.	14.	23.	21.	46.	53.	92.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
$Ca(NO_3)_2$	.008	.011	.012	.012	.012	.011	.013	.015	.015	.017	.016
$NaNO_3$	.010	.013	.018	.018	.018	.020	.018	.016	.019	.020	.021
KNO_3	.008	.013	.018	.018	.016	.020	.020	.020	.018	.020	.020
KCl	.010	.013	.015	.015	.010	.015	.020	.019	.020	.020	.018
$(NH_4)_2SO_4$	.010	.013	.020	.020	.020	.018	.020	.018	.020	.020	.020
$NaCl$	.010	.015	.020	.020	.020	.018	.020	.020	.020	.020	.022
KS_2O_4	.010	.012	.015	.016	.015	.015	.015	.019	.020	.020	.016
$CaH_4(PO_4)_2$	.009	.011	.010	.011	.011	.012	.011	.011	.010	.010	.010
KH_2PO_4	.008	.012	.013	.012	.012	.013	.012	.015	.015	.015	.014
$NaC_2H_3O_2$	.010	.014	.018	.017	.017	.020	.020	.020	.020	.020	.021
Check	.008	.010	.010	.011	.010	.010	.011	.012	.012	.012	.014

TABLE 18.—*Rate and extent of solubility of powdered gneiss which was treated will salt solutions and then washed until all the readily soluble salts were eliminated. Ratio of powdered rock to distilled water was about 1 to 0.75 and mixture maintained at room temperature. Figures represent freezing point depression.*

Days.	0.	1.	2.	4.	14.	22.	30.	45.	52.	91.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
$Ca(NO_3)_2$	.010	.013	.013	.010	.012	.012	.009	.012	.011	.012
$NaNO_3$	.010	.013	.012	.012	.012	.013	.013	.014	.012	.014
KNO_3	.010	.013	.012	.013	.012	.012	.011	.014	.013	.015
KCl	.010	.013	.013	.014	.014	.015	.016	.016	.014	.014
$(NH_4)_2SO_4$	.010	.011	.014	.015	.015	.016	.016	.015	.016	.017
$NaCl$	.010	.013	.012	.013	.012	.014	.014	.012	.012	.013
K_2SO_4	.010	.013	.012	.014	.010	.013	.012	.012	.012	.015
$CaH_4(PO_4)_2$	.010	.011	.012	.012	.010	.010	.010	.010	.012	.010
KH_2PO_4	.010	.012	.012	.012	.012	.013	.013	.011	.013	.012
$NaC_2H_3O_2$	.010	.012	.012	.012	.010	.013	.013	.016	.019	.019
Check	.009	.010	.010	.010	.010	.009	.010	.010	.010	.010

TABLE 19.—*Rate and extent of solubility of orthoclase which was first treated with salt solutions and then washed until all soluble salts were eliminated. Ratio of mineral to distilled water was about 1 to 0.75 and mixture maintained at room temperature. Figures represent freezing point depression.*

Days.	0.	1.	2.	3.	5.	14.	23.	31.	46.	53.	92.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
$Ca(NO_3)_2$	.007	.010	.010	.010	.010	.010	.011	.011	.011	.012	.012
$NaNO_3$	.008	.008	.009	.011	.011	.012	.012	.012	.021	.016	.017
KNO_3	.008	.008	.008	.010	.010	.011	.011	.012	.012	.013	.014
KCL	.007	.008	.007	.010	.010	.010	.010	.012	.012	.012	.014
$(NH_4)_2SO_4$	.009	.009	.010	.010	.011	.011	.014	.014	.014	.014	.015
NaCl	.008	.008	.009	.010	.011	.012	.012	.012	.013	.013	.014
K_2SO_4	.007	.007	.008	.008	.010	.010	.012	.012	.012	.012	.013
$CaH_4(PO_4)_2$	.006	.006	.006	.006	.007	.007	.007	.007	.009	.009	.010
KH_2PO_4	.008	.008	.008	.008	.009	.009	.009	.010	.010	.011	.012
$NaC_2H_3O_2$	.009	.009	.010	.010	.011	.012	.012	.012	.014	.014	.016
Check	.005	.005	.006	.006	.008	.008	.008	.010	.010	.010	.012

The above data show that the treatments of the rocks and minerals used with the various salt solutions influenced very little if any the rate and extent of their solubility. It will be readily seen that the increased solubility is very slight over the checks. The greatest increase generally occurred in the $(NH_4)_2SO_4$, $NaNO_3$, NaCl and $NaC_2H_3O_2$ treatments and the least in $CaH_4(PO_4)_2$ and KH_2PO_4.

The treatment of salts, therefore, did not have as marked influence on the solubility of rocks and minerals as they did on soils. The results with rocks and minerals resemble very much those of quartz sand.

THE SOLUBILITY OF ROCKS AND MINERALS IN THE PRESENCE OF SALTS

In the preceding study only the residual effect of salt treatments on the solubility of rocks and minerals could be studied. In order to ascertain if the presence of salts for long periods in contact might have a greater effect upon the solubility of rocks and minerals, an investigation upon this subject was undertaken. It consisted of treating 20 grams of powdered rocks and minerals with 15cc. of N/10 solutions of $Ca(NO_3)_2$, $NaNO_3$, KNO_3, KCl, $(NH_4)_2SO_4$, NaCl, K_2SO_4, $CaH_4(PO_4)_2$, KH_2PO_4 and $NaC_2H_3O_2$, and determining the freezing point immediately and at various intervals thereafter for long periods. The solubility effect and reaction could be ascertained from the difference in the freezing point depression between that of the solution alone and of the solution and solid, and from the difference in the freezing point depression at the various periods. Some of the typical results obtained are detailed in tables 20 to 22 inclusive.

TABLE 20.—*Rate and extent of solubility of amphibole in presence of salts. Ratio of liquid to solid 1 to 0.75 and mixture maintained at room temperature.*

Days.	0.	1.	5.	15.	24.	35.	Freezing point depression of salt solutions alone.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.
$Ca(NO_3)_2$	.558	.558	.558	.559	.559	.560	.561
KCL	.409	.409	.409	.410	.410	.412	.417
$(NH_4)SO_2$	.254	.255	.255	.263	.265	.269	.269
$CaH^4(PO_4)_2$	.144	.042	.018	.018	.018	.018	.200
KH_2PO_4	.117	.080	.070	.070	.070	.070	.148
NaCl	.390	.391	.397	.398	.402	.405	.412
$NaC_2H_3HO_2$	.397	.397	.399	.399	.399	.402	.406
Check	.015	.015	.017	.017	.019	.020	......

TABLE 21.—*Rate and extent of solubility of biotite granite in presence of salts. Ratio of solid to liquid 1 to 0.75 and mixture maintained at room temperature.*

Days.	0.	2.	4.	11.	19.	31.	44.	Freezing point depression of salt solutions alone.
	C°	C°	C°	C°	C°	C°	C°	C°
$Ca(NO_3)_2$	.553	.554	.555	.555	.554	.555	.556	.561
KNO_3	.362	.362	.363	.365	.365	.365	.366	.375
KCl	.405	.405	.405	.405	.406	.408	.412	.417
$(NH_4)_2SO_4$	.255	.258	.260	.260	.260	.262	.264	.269
$CaH_4(PO_4)_2$	.143	.030	.019	.019	.017	.017	.013	.200
KH_2PO_4	.129	.087	.078	.075	.075	.075	.075	.048
NaCl	.393	.393	.395	.399	.414	.414	.416	.412
$NaC_2H_3O_2$	.398	.398	.398	.400	.400	.402	.405	.406
Check	.020	.021	.023	.023	.024	.025	.025	......

TABLE 22.—*Rate and extent of solubility of prochlorite in presence of salts. Ratio of solid to liquid 1 to 0.75 and mixture maintained at room temperature.*

Days.	0.	1.	2.	8.	14.	21.	34.		Freezing point depression of salt solutions alone.
	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.	C°.
$Ca(NO_3)_2$	.550	.550	.550	.550	.555	.555	.555	......	.561
KNO_3	.360	.360	.361	.361	.360	.360	.360	.361	.375
KCl	.403	.401	.403	.403	.404	.404	.405	......	.417
$(NH_4)SO_4$	.256	.256	.256	.260	.260	.260	.260	......	.269
$CaH_4(PO_4)_2$	.135	.180	.073	.040	.032	.023	.023	......	.200
KH_2PO_4	.125	.113	.110	.085	.085	.080	.080	......	.148
NaCl	.396	.397	.397	.397	.398	.398	.402	......	.412
$NaC_2H_3O_2$	.388	.388	.393	.393	.393	.401	.407	......	.406
Check	.017	.017	.018	.019	.019	.020	.023	......	....

The above experimental data reveal at least five very interesting points: (1) that the reaction between the salt solutions and rocks and minerals is very rapid if not almost instantaneous; (2) in all of the rocks and minerals and in all of the salt solutions, the freezing point depression of the mixture was slightly smaller than in the solutions alone, indicating that there was a reaction between the solvent and the solute or solid; (3) with the exception of the $CaH_4(PO_4)_2$ and KH_2PO_4 mixtures, the depression in all of the other mixtures remained almost constant, with a very slight tendency to increase; (4) the depression of all the $CaH_4(PO_4)$ and KH_2PO_4 treated rocks and minerals decreased very greatly, indicating that the phosphate was being abstracted by the powdered rocks and minerals; (5) salts had very little, if any, increasing effect on the solubility of the various rocks and minerals.

It will be of interest to mention here that the treatment of rocks and minerals with salts yielded exactly the same type of results as soils similarly treated (4).

SUMMARY

In the present paper there are presented the results of an investigation on the rate and extent of solubility of the most common soil-forming rocks and minerals at different moisture contents, under different salt treatments, and at various temperatures.

The method employed in measuring the rate and extent of solubility was the freezing point method. This method proved quite appropriate for the purpose.

It was found that when very fine powder of rocks and minerals in the unleached condition was mixed with distilled water in the ratio of 1 of solid to 0.75 of water, the amount of material that went into solution immediately was quite appreciable in all the rocks and minerals and in some rocks and minerals more than in others. The freezing point depression for instance, varied from 0.008C° in quartz to 0.057° in ferrugineous sandstone, to 0.069° in apophyllite. Expressing these depressions in p.p.m. of solution then the concentration varies from 100 p.p.m. in quartz to 711 in ferrugineous sandstone, to 975 in apophyllite.

At a lower moisture content the freezing point depression and consequently the concentration, is considerably greater in most of the rocks and minerals.

When the powdered rocks and minerals are leached with distilled water the freezing point depression is greatly decreased in all of them, with few exceptions. These results go to show that the material in the finely powdered rocks and minerals which goes very readily into solution, is washed away, and its place is not immediately taken by other soluble material, with few exceptions.

At room temperature the rate and extent of solubility of the rocks and minerals both in the leached and unleached condition are very small after the initial solubility, even for a period of over 100 days. The increase is only about 0.010° C or less at the end of 107 days. With few exceptions, the leached rocks and minerals did not attain the same degree of freezing point depression or concentration of solution, as existed before leaching.

In few rocks and minerals, especially in shale and serpentine, there is a tendency for the initial material in solution to go out of solution, or at least the freezing point depression decreases with lapse of time. This is true mainly at room temperature.

At the temperature of 53° C for 95 days and at the steam pressure of 26 pounds for 8 hours, the rate and extent of solubility both in the leached and unleached condition were greatly increased in all the rocks and minerals, excepting the shale and kaolinite. Thus, at the temperature of 53° C and in the unleached condition the depression of a biotite granite rose from 0.019° to 0.083°, in pegmatite from 0.025° to 0.137°, in quartzite from 0.020° to 0.132 , in siliceous sandstone from 0.030° to 0.058C°. In the leached condition it rose in amphibole from 0.010° to 0.124°, in chrysolite from 0.005° to 0.220°, in quartz from 0.007° to 0.357°, in serpentine from 0.020° to 0.340° etc.

Of all the results the most surprising and unexpected were those yielded by the quartz and the quartzites at the higher temperatures. These materials gave the highest solubility product, with one or two exceptions. The quartz gave a solubility of 0.357°, the three varieties of quartzite 0.113°, 0.132°, and 0.152° respectively. This is indeed a tremendous solubility for these materials. They were, however, not absolutely pure but the material in solution consisted almost entirely of silica.

A very interesting and significant point in regard to the solubility of many rocks and minerals and especially of the siliceous materials, is the fact that the rate of solubility at the temperature of 53° was not most rapid at the beginning but after a long time. This phenomenon would seem to suggest the theory that the rocks and minerals required a certain length of time under this temperature before they began to decompose or hydrolyze rapidly.

The materials whose solubility was not increased by the higher temperatures were shale and kaolinite.

The initial depression of shale and of one variety of the ferrugineous sandstone, decreased even at the highest temperature.

Although at room temperature the solubility of all the rocks and minerals became practically stationary immediately, at the temperature of 53°C it continued to go on, even at the end of 95 days without any apparent signs of stopping, and in some of them it progressed with increased velocity.

The material which goes into solution at the high temperature still persists when the mass is cooled to -3°C indicating that equilibrium or the sat-

uration point was not yet attained at the high temperature at the end of 95 days.

The solubility product of the rocks and minerals at the ratio of 5 of water to 1 of solid, was greatly smaller than that at the ratio of 1 of water to 0.75 of solid, at room temperature. At the temperature of 53°C it was about the same at both ratios.

The results as a whole point to two outstanding conclusions: (1) that the rocks and minerals employed, with few exceptions, do not show a definite solubility as definite compounds do; and (2) the equilibrium attained in solubility at the various moisture contents and temperatures is only apparent and not real or absolute.

A consideration of the nature and composition of the rocks and minerals together with the type of their reaction with water, makes the above experimental facts and conclusions appear reasonable and logical.

The large increase in soluble content in the rocks and minerals at the higher temperatures is probably largely the result of hydrolysis.

All the rocks and minerals employed without a single exception reacted alkaline, using phenolphthalein and red litmus paper as indicators. There were few rocks and minerals which failed to show alkalinity with phenolphthalein but they turned red litmus blue very readily.

The marked increasing effect of the higher temperatures on the solubility of rocks and minerals goes to prove that the large increase in solubility obtained in soils at similar high temperatures was not due wholly to the decomposition of the organic matter content but also to the solubility and hydrolysis of the mineral particles of the soils.

Treating the rocks and minerals with salt solutions and then washing them until free of soluble salts, had very little if any effect upon the rate and extent of solubility, at ordinary temperature.

Even when the salts were allowed to remain in contact with the rocks and minerals for long time the solubility was very little if any increased, at ordinary temperature.

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(2) Bouyoucos, G. J. and McCool, M. M. Further Studies on the Freezing Point Lowering of Soils. Tech. Bul. 31. Mich. Agr. Expt. Sta., 1916.

(3) Extensive bibliographs upon the solubility of rocks and minerals will be found in U. S. Bureau of Soils, Bulletin No. 3 (1905), by Frank K. Cameron and James M. Bell; and in Soil Science of October, 1919 in an article by E. De Turk entitled "Potassium Bearing Minerals as a source of Potassium for Plant Growth."

(4) Bouyoucos, G. J. and Laudeman, W. A. The Freezing Point Method as a New Means of Studying Velocity of Reaction Between Soil and Chemical Agents and Behavior of Equilibrium. Mich. Expt. Station Technical Bulletin No. 37, 1917.

STUDIES ON THE REACTIONS BETWEEN SOILS AND VARIOUS CHEMICAL COMPOUNDS

Technical Bulletin No. 51

BY C. H. SPURWAY, SOILS SECTION

THE PROBLEM

Investigations on the solubility of soils and effects of soluble salt treatments on the solubility of soils, rock powders and miscellaneous materials have been undertaken in this laboratory and some of the results have been published. See Bouyoucos and McCool (1), Bouyoucos and Laudeman (2), McCool and Millar (5) and Bouyoucos (3, 4). Chemical analyses of several soil extracts from various treatments have been made. Spurway (7) showing immediate and residuary effects from a general chemical standpoint. In order to more accurately interpret the reactions between soils and chemicals commonly applied as fertilizers, however, it was considered necessary to extend the researches to a study of the effects of these compounds on soils of different kinds, bearing in mind the nature of the soils as well as the character of the fertilizer salts and other compounds used. Accordingly a study of fixation in soils of different classes, acid and alkaline to litimus paper was undertaken in an attempt to determine, if possible, the nature of the reactions and soil components involved and to throw more light on the phenomena of fixation in soils and its practical significance particularly with respect to the disposition of nutrient elements of applied fertilizers in various soil classes.

Whatever may be the true explanation of the processes involved in these reactions it is apparent that further progress in this line of work depends in a large measure on increasing our knowledge concerning the chemical constitution of soils, and the practical significance of various soil components, and devising methods for quantitative determinations of these components.

HISTORICAL

A review of the literature concerning the effects of chemical compounds on soils and various other materials particularly with respect to the phenomena known as "adsorption"; "absorption" and "fixation and exchange of bases" revealed the fact that considerable work had been done by investigators working along these lines. These investigations have brought forth many valuable basic data establishing principles by abundant proofs, together with a number of conflicting results and opinions. After studying the work of many investigators pertaining to the subject at hand the author was led to conclude that when conflicting results occurred they were probably due to the use of various substances of dissimilar chemical composition, in conjunction with chemical compounds of different classes, and also to the use of a diversity of methods.

Because of the fact that reviews of this literature have been made in con-

nection with the work of other investigators and that considerable space would be required to treat the subject satisfactorily it was considered inexpedient and unadvisable to give a complete review of the subject literature here. The work of Prescott (6) gives in a concise form the salient points of the research in this field and the reader is referred to this work as being representative of the general situation. A list of cited references to literature on the subject under discussion is given at the end of this publication.

The whole field of experimentation along this line appears to be permeated by three schools of though. Some investigators favor the claim that the reaction between chemical compounds and soils and other substances is in general a chemical process, while others are inclined to the opinion that the phenomena involved can be explained by the action of physical forces, and still others combine physical and chemical laws in explanation of their results.

EXPERIMENTAL

METHOD OF PROCEDURE

The research reported in this publication was designed primarily to study reactions between neutral salts, bases and hydrolyzing salts and alkaline and acid soils of various classes. In order to eliminate, as much as possible the possibility of secondary and continuous reactions as undoubtedly occur in percolation methods, the decantation method was used. The experimental procedure, except where otherwise noted, consisted in bringing together 100 gm. of air dried soil and 500 c.c. of solution into intimate contact at laboratory temperature in glass containers for a period of time of one hour, and the soil solution separated by decanting and filtering through paper. The soil extracts were analyzed by standard methods for the substance under consideration. Results are reported in grams except where otherwise noted. Computations were based on 500 c.c. of extract.

EFFECTS OF NEUTRAL SALTS

Fixation of Potassium from KCl and Liberation of Calcium from a Series of Miscellaneous Soils

The effects of a KCl solution on a series of miscellaneous soils were first studied in an attempt to correlate the degree of fixation of potassium with some soil characteristic. Table 1 contains the results of this investigation obtained from 24 soils collected from the glacial formations common to central Michigan. The table is divided into two sections based on the presence or absence of carbonates in the soils as determined by the HCl test, and the results are presented in order of increasing quantities of potassium fixed by the soils. These soils were dried in the air and passed through a 2 m.m mesh sieve.

TABLE 1.—*Reaction, soil class, potassium fixed from KCl, calcium and chlorine in solution and calcium and SiO_2 dissolved by 0.2 N HCl. Potassium added 0.391 gm. Chlorine added 0.3546 gm.*

(Results in grams per 100 grams of soil).

No.	Reaction	Soil class.	Potassium fixed.	Calcium in solution.	Chlorine in solution.	Dissolved by 0.2 N HCl	
						Calcium.	SiO_2
		(Non-carbonate soils.)					
9	ac	Medium sand....	0.0331	0.0109	0.3620	0.0248	0.0310
21	ac	Medium sand....	0.0332	0.0114	0.3620	0.0318	0.0320
20	ac	Medium sand....	0.0363	0.0124	0.3620	0.0233	0.0390
23	ac	Medium sand....	0.0410	0.0144	0.3620	0.0315	0.0320
14	ac	Sandy loam......	0.0488	0.0198	0.3620	0.0474	0.0480
13	ac	Sandy loam......	0.0496	0.0158	0.3632	0.0406	0.0365
24	ac	Sandy loam......	0.0510	0.0203	0.3620	0.0740	0.0510
2	ac	Sandy loam......	0.0537	0.0203	0.3638	0.0764	0.0510
27v	al	Sandy loam......	0.0557	0.0228	0.3620	0.0780	0.0520
22	ac	Silt loam........	0.0665	0.0272	0.3582	0.0746	0.0555
8	al	Silt loam........	0.0714	0.0272	0.3582	0.1048	0.0690
15	al	Sandy loam......	0.0910	0.0332	0.3638	0.1091	0.0505
11	al	Silt loam........	0.1004	0.0302	0.3657	0.1456	0.1140
		(Carbonate soils.)					
23v	al	Medium sand....	0.0369	0.0158	0.3582	0.0678	0.0530
7	ac	Sandy loam......	0.0548	0.0223	0.3582	0.0554	0.0335
19	al	Sandy loam......	0.0650	0.0242	0.3620	0.1789	0.0730
4	al	Loam...........	0.0665	0.0297	0.3638	0.0654	0.0615
18	al	Sandy loam......	0.0685	0.0262	0.3582	0.1141	0.0685
6	ac	Loam...........	0.0705	0.0321	0.3620	0.0428	0.0480
3	al	Sandy loam......	0.0764	0.0356	0.3620	0.1599	0.0665
1	al	Sandy loam......	0.0848	0.0386	0.3582	0.1127	0.0785
5	al	Loam...........	0.0860	0.0391	0.3620	0.0849	0.0715
26	al	Silt loam........	0.1293	0.0554	0.3620	0.2061	0.1030
25	al	Silt loam........	0.1808	0.0802	0.3620	0.6440	0.1740

The reaction of the soils as indicated in Table 1 was determined by the litmus paper test. It may be observed that some non-carbonate soils gave an alkaline reaction and some carbonate soils gave an acid reaction. The acid reaction of the carbonate soils may be explained on the basis that the carbonates present were composed of coarse particles widely distributed through the soil mass, a point observed during the testing operation for the presence of carbonates. The alkalinity of the non-carbonate soils may be due to the presence of carbonates in too small quantities to be observed by the acid test or to alkaline silicates. The most important feature of this table is the general agreement between the quantities of potassium fixed and of calcium found in the solutions in all the soils and also between

the quantities of potassium fixed and of calcium and SiO_2 dissolved by 0.2 N HCl in the non-carbonate soils. This general agreement of results leads to the conclusion that soil calcium in some definite combination, probably as silicate, may be largely responsible for the fixation of potassium from KCl. A large number of chemical determinations have been made on these soils and some of these results have been published, Spurway (8), but no correlations with fixation of potassium from KCl except those shown in Table 1 have been observed. There is no evidence of fixation of chlorine from the KCl by the soils used in this experiment, and from this standpoint the results are in agreement with those of many other investigators. Other observations made in connection with the soils under discussion are as follows: (1) All the solutions were alkaline to red litmus paper except those from soils No. 20 and 23. (2) The quantities of chlorine added to the solutions were in excess of the quantities required to combine with the potassium and calcium found by analysis, therefore, other chlorides were present The reaction of the solutions indicates that iron or aluminum may not have been present as chlorides at least in any appreciable quantities, and the observed excess of chlorine may have been combined with sodium or magnesium. The investigation was continued along similar lines in order to settle this point if possible.

The following experiments were limited to a smaller number of soils. Eight soils were selected of four principal classes as follows: medium sand, sandy loan, silt loam and clay loam including an alkaline and acid soil of each class. All them alkaline soils were especially low in carbonate content except the alkaline medium sand which contained carbonate from applied limestone. These soils were dried in the air, passed through a 2 m.m. mesh sieve and treated the same as the soils in the foregoing experiment. The soil classes are indicated by their initials in the tables and the reaction refers to the litmus paper test. Results are reported in Table 2.

Fixation of Potassium from KC1 and Liberation of Calcium and Magnesium from a Series of Alkaline and Acid Soils of Various Classes

TABLE 2.—*Fixation of potassium from KC1 and quantities of soil elements found in the solutions. Potassium added 0.391 gm. Chlorine added 0.3546 gm.*

Soil and Reaction	Potassium fixed.		Found in solution		Potassium equivalent to calcium and magnesium.
	Untreated soils.	Washed with HCl	Calcium.	Magnesium.	
M. S. al......	0.0510	0.0132	0.0254	....	0.0496
M. S. ac......	0.0352	0.0019	0.0177	....	0.0345
S. L. al......	0.1054	0.0379	0.0410	0.0058	0.0987
S. L. ac......	0.0553	0.0069	0.0199	0.0047	0.0540
St. L. al......	0.1135	0.0519	0.0360	0.0129	0.1118
St. L. ac......	0.0934	0.0294	0.0340	0.0081	0.0924
C. L. al......	0.1780	0.0760	0.0650	0.0150	0.1751
C. L. ac......	0.1793	0.0577	0.0660	0.0145	0.1753

As shown in Table 2, the quantities of potassium fixed from the KC1 solutions by this second series of soils were closely equivalent to the quantities of calcium and magnesium found in the solutions. An attempt was made to determine sodium in the solutions from the clay loam soils but the quantities of this element present were considered too small for quantitative gravimetric determination and hence relatively insignificant. The soil solutions obtained in this experiment were also alkaline to red litmus paper but it was not necessary to consider that iron, aluminum or sodium were present in the solutions combined with chlorine in order to account for practically all of the chlorine in the solutions not combined with potassium; the quantities of calcium and magnesium found were very nearly sufficient for this purpose. The reaction was apparently chiefly between the KC1 solutions and the calcium and magnesium of the soils.

All the alkaline soils except the clay loam showed greater fixation of potassium and more calcium and magnesium in their solutions than did the acid soils of the same class. The increase in the fixation of potassium shown by the acid clay loam over the other member of this class, however, was accompanied by a corresponding increase in quantity of calcium found in its solution, and this effect may also be notes in subsequent experiments with these clay loam soils where fixation apparently depends on soil calcium. Treating the soils with HC1 and then washing thoroughly with distilled water greatly lowered the degree of fixation of potassium as shown in Table 2. This effect was considered to be due to the removal of calcium and magnesium by the acid treatment. These results also strongly indicate that soil calcium and magnesium may be the principal cause of fixation of potassium in the soils under experimentation.

The conclusion seems justified that the reaction was practically entirely between the neutral salt solution and calcium and magnesium of the soils in a silicate combination. The soil factor determining the degree of fixation of potassium is apparently the quantity of calcium and magnesium in the soils in condition to react with the salt solution, the soil calcium having by far the greater influence. It is recognized, however, that certain soils may contain other elements in replaceable combinations and the proportions of these elements may vary, and also, results may vary with varying concentrations of salt solutions.

Fixation of Potassium from K_2SO_4 and KNO_3 and of Ammonia from $(NH_4)_2SO_4$

Other salts of potassium, namely, K_2SO_4 and KNO_3 and also $(NH_4)_2SO_4$ were used in a manner similar to KC1 in order to study their effects on the series of different soil classes. Table 3 contains the results of this phase of the subject.

Attention is called to the principal features of the results presented in Table 3, as follows: Fixation of potassium from K_2SO_4 and KNO_3 was closely equivalent in quantity to that fixed from KC1 by these soils and the quantities of soil calcium exchanged were also closely equivalent. Quantities of NH_4 fixed, however, were not closely equivalent to those of potassium fixed from the salts used, being somewhat smaller, and were also not in similar agreement with the quantities of calcium exchanged, although quantities of calcium liberated by the NH_4 - ion were closely comparable to those found in the solutions from the potassium salts treatments. While differences must be recognized between the effects of the potassium and ammonia in the experi-

ment, the fact that the fixation of ammonia correlates with the exchange of calcium indicates that the same general causes are operating in each case although perhaps to a different degree. The analytical determinations may have been influenced by ammonia from soil organic matter since the results for fixed NH_4 are lower than the potassium equivalents. More of the cations of the salts was fixed by the alkaline soils of similar classes than the acid soils, except, again, the acid clay loam which fixes more of the cations and liberates more calcium than the alkaline clay loam. There was no evidence of fixation of anions from these salts.

TABLE 3.—*Fixation of potassium from K_2SO_4 and KNO_3 and ammonia from $(NH_4)_2SO_4$.*

Potassium added 0.391 gm. SO^4 added 0.4803 gm.
Potassium added 0,381 gm. NO^3 added 0.620 gm.
NH^4 added 0.1804 gm. SO^4 added 0.4803 gm.

Soil and reaction.	K^2SO_4.			KNO_3			$(NH_4)_2SO_4$		
	Potassium fixed.	Calcium in solut'n.	SO_4 in solut'n.	Potassium fixed.	Calcium in solut'n.	NO_3 in solut'n.	NH_4 fixed.	Calcium in solut'n.	SO_4 in solut'n.
M. S. al.....	0.0500	0.0239	0.4872	0.0491	0.0228	0.629	0.0221	0.0204	0.5276
M. S. ac....	0.0364	0.0127	0.4847	0.0366	0.0132	0.638	0.0166	0.0117	0.5284
S. L. al.....	0.1086	0.0421	0.4979	0.1071	0.0401	0.645	0.0472	0.0401	0.5284
S. L. ac....	0.0562	0.0198	0.5242	0.0543	0.0183	0.617	0.0193	0.0167	0.5160
St. L. al.....	0.1216	0.0441	0.4872	0.1191	0.0436	0.633	0.0480	0.0401	0.5127
St. L. ac....	0.1028	0.0406	0.5020	0.0986	0.0395	0.625	0.0372	0.0376	0.5201
C. L. al.....	0.1863	0.0695	0.5201	0.1740	0.0609	0.625	0.0633	0.0578	0.5324
C. L. ac....	0.1892	0.0700	0.5136	0.1756	0.0629	0.638	0.0732	0.0624	0.5267

Fixation of Calcium and Magnesium from Neutral Salts

Since the foregoing data indicate that the fixation of potassium and ammonia by the soils may be due chiefly to the quantity of calcium and magnesium contained in them in condition to react, it was considered advisable to experiment with calcium and magnesium salts to determine their relationships. Accordingly the soils were treated with solutions of $Ca(NO_3)_2$, $CaSO_4$, $CaCl_2$ and $MgCl_2$, the experimental procedure being the same as that followed in previous cases. Tables 4 and 5 contain the results of this experiment.

TABLE 4.—*Fixation of calcium from $Ca(NO_3)_2$ and $CASO_4$.*

Calcium added 0.4019 gm. NO^3 added 1.260 gm.
Calcium added 0.3085 gm. SO^4 added 0.7423 gm.

Soil and reaction.	$Ca(NO_3)_2$.		$CaSO_4$.	
	Calcium fixed.	NO_3 in solution.	Calcium fixed.	SO_4 in solution.
M. S. al	0.0040	1.260	0.0020	0.7472
M. S. ac	0.0032	1.260	....	0.7440
S. L. al	0.0203	1.291	0.0121	0.7505
S. L. ac	0.0142	1.291	0.0020	0.7514
St. L. al	0.0304	1.260	0.0223	0.7480
St. L. ac	0.0183	1.291	0.0101	0.7472
C. L. al	0.0446	1.291	0.0304	0.7522
C. L. ac	0.0426	1.291	0.0284	0.7497

TABLE 5.—*Fixation of calcium and magnesium from the chlorides.*

Calcium added 0.408 gm. Chlorine added 0.7092 gm.
Magnesium added 0 2581 gm.
Chlorine added 0 7523 gm.

Soil and reaction.	$CaCl_2$.			$MgCl_2$			
	Calcium fixed.	Chlorine in solut'n.	Calcium fixed after magnesium treatment.	Magnesium fixed.	Calcium in solut'n.	Chlorine in solut'n.	wt. calcium / wt. magnesium.
M. S. al	0.0036	0.7090	0.0258	0.0332	0.0515	0.7577	1.551
M. S. ac	0.0020	0.7090	0.0080	0.0112	0.0178	0.7553	1.589
S. L. al	0.0102	0.7165	0.0555	0.0510	0.0792	0.7573	1.553
S. L. ac	0.0041	0.7128	0.0218	0.0185	0.0277	0.7530	1.497
St. L. al	0.0142	0.7165	0.0164	0.0430	0.0693	0.7612	1.605
St. L. ac	0.0102	0.7165	0.0357	0.0385	0.0594	0.7596	1.543
C. L. al	0.0315	0.7165	0.0575	0.0686	0.1128	0.7569	1.644
C. L. ac	0.0305	0.7165	0.0580	0.0708	0.1168	0.7596	1.650

Tables 4 and 5 contain some interesting and important results and establish quite conclusively that the fixation of calcium in these soils depends upon their content of replaceable magnesium and the fixation of magnesium upon their content of replaceable calcium. The alkaline soils fixed greater quantities of calcium and magnesium than did the acid soils of the same class except, again, the acid clay loam which fixed a greater quantity of magnesium and released a greater quantity of calcium than the alkaline clay loam, a result comparing with the fixation of potassium and ammonia by these soils from the salts studied. The alkaline clay loam, however, fixed more calcium from the calcium salts and released more magnesium from the potassium and ammonia treatments than did the acid clay loam. Mag-

nesium was not determined in case of the calcium salts treatments, but the order of magnitude of calcium fixation in these experiments follows closely the order of quantity of magnesium liberated from the soils as shown in Table 2. Also, much greater quantities of calcium were fixed by the soils after treatment with a $MgCl_2$ solution containing 0.2581 gm. magnesium per 500 c.c. of solution, and thorough washing, as shown in Table 5, column 4; evidence that the fixation of calcium in these cases depended upon the quantity of magnesium in the soils in condition to react. Closely equivalent relationships between magnesium fixed from $MgCl_2$ and calcium found in the soil solutions are shown in Table 5, the exact equivalent ratio in this case being 1.6476. Also, calcium and magnesium were not fixed by the various soils in equivalent quantities showing that different soil factors were operating in each case. Anions of the calcium and magnesium salts were not fixed by the soils to any great extent at least, and the solutions from all the calcium and magnesium salt treatments were alkaline to red litmus paper.

Reversibility of the Fixation Processes

It was previously shown that the fixation of magnesium by the soils was reversed by a calcium salt treatment and that the magnesium treated soils fixed much more calcium than the same soils in a natural state. Another experiment was made to determine the reversibility of other fixed cations by causing cations to be fixed in soils and then treating with salts containing other cations. In this experiment the alkaline and acid sandy loam soils were used, with the chlorides of potassium, sodium, calcium and magnesium. No attempt was made to fix calcium in the untreated soils because the small quantities of calcium fixed by the soils makes the experimental procedure more difficult. Proportions of soils and solutions were the same as used for the KCl treatments, namely, 100 gms. of soil and 500 c.c. of a 0.02 N salt, solution. Results and further explanations of this experiment are given in Table 6. Fixed cation equivalents were determined by computing from the quantities of cations found in the solutions as shown in the table, other than those used in the final treatments, the quantities necessary to be fixed to satisfy the respective gram-equivalent ratios.

TABLE 6.—(A) *Alkaline and acid sandy loam soils treated with KCl Solution. Washed thoroughly with with distilled water, then treated separately with NaCl, $CaCl_2$ and $MgCl_2$ solutions.*

Soils and reaction.	Cations fixed.	Potassium in solution.	Sodium in solution.	Calcium in solution.	Magnesium in solution.	Fixed cation equivalents.
S. L. al.......	Na 0.0610	0.0831	0.1690	0.0049	0.0034	0.0609
S. L. ac.......	Na 0.0240	0.0309	0.2060′	0.0029	0.0024	0.0260
S. L. al.......	Ca 0.0481	0.0744	....	0.1523	0.0074	0.0505
S. L. ac.......	Ca 0.0231	0.0393	....	0.1773	0.0035	0.0259
S. L. al.......	Mg 0.0317	0.0292	....	0.0376	0.0899	0.0319
S. L. ac.......	Mg 0.0133	0.0133	....	0.0158	0.1083	0.0137

(*B*) *Alkaline and acid sandy loam soils treated with NaCl Solution, Washed, then treated separately with KCl, $CaCl_2$ and $MgCl_2$ solutions.*

Soils and reaction.	Cations fixed.	Potassium in solution.	Sodium in solution.	Calcium in solution.	Magnesium in solution.	Fixed cation equivalents.
S. L. al.......	K 0.1303	0.2607	0.0472	0.0145	0.0059	0.1275
S. L. ac.......	K 0.0728	0.3182	0.0323	0.0069	0.0035	0.0797
S. L. al.......	Ca 0.0540	0.0044	0.0482	0.1464	0.0071	0.0559
S. L. ac.......	Ca 0.0242	0.0017	0.0231	0.1762	0.0035	0.0268
S. L. al.......	Mg 0.0432	0.0031	0.0492	0.0297	0.0784	0.0440
S. L. ac.......	Mg 0.0182	0.0023	0.0172	0.0158	0.1034	0.0194

(*C*) *Alkaline and acid sandy loam soils treated with $MgCl_2$ solution, washed and then treated separately with KCl, NaCl and $CaCl_2$ solution.*

Soil and reaction.	Cations fixed.	Potassium in solution.	Sodium in solution.	Calcium in solution.	Magnesium in solution.	Fixed cation equivalents.
S. L. al.......	K 0.0955	0.2955	....	0.0036	0.0300	0.1024
S. L. ac.......	K 0.0449	0.3461	....	0.0021	0.0142	0.0481
S. L. al.......	Na 0.0568	....	0.1732	trace	0.0305	0.0577
S. L. ac.......	Na 0.0289	....	0.2011	trace	0.0174	0.0329
S. L. al.......	Ca 0.0499	....	....	0.1505	0.0345	0.0568
S. L. ac.......	Ca 0.0242	....	....	0.1762	0.0194	0.0320

Results in Table 6 show the reaction to be reversible in all cases studied, and the gram equivalent ratios closely approached without considering iron and aluminum present as chlorides. In (b) portion of the table are shown some results from determinations of potassium after the $CaCl_2$ and $MgCl_2$ retreatments. These quantities of potassium are about the same magnitude as could be expected from solubility effects varying from about four to nine parts per million of solution, and it is assumed that potassium plays an unimportant part in these fixation processes. Another very important relationship is also shown by this experiment in that after each preliminary treatment the several cations used were fixed by the soils in nearly equivalent quantities. In this connection it should be remembered that not all of the soil calcium or magnesium in a condition to react would be removed by the preliminary salt treatments although all of the solutions used were equal in concentration.

CONCLUSIONS CONCERNING THE NEUTRAL SALT TREATMENTS

The principal points observed in this investigation with the neutral salts may be briefly summarized as follows: (1) All the soils, except the medium sand containing limestone and in the case of calcium, precipitated the cations of the neutral salts used and held them fixed in the soil mass. (2) The anions of the neutral salts were not fixed to any great extent by the soils. (3) Fixation of cations was accompanied by a closely equivalent liberation of other soil elements particularly calcium and magnesium and the other elements artifically fixed in the soils. (4) The fixation of potassium from KCl by

carbonate and non-carbonate soils closely correlated with the quantities of calcium found in the soil solutions. (5) The fixation of potassium from KC1 also correlated somewhat with the quantities of calcium and SiO_2 dissolved from the non-carbonate soils by 0.2 N HC1. (6) Except in two cases, soils No. 20 and 23 with KC1 treatment, all the solutions were alkaline to red litmus paper. (7) Iron and aluminum were undoubtedly present in many of the solutions but no evidence was found that these elements were combined with the anions of the neutral salts used. (8) Potassium and sodium probably played an unimportant part in the experiments performed on soils not previously treated with salts of these elements. (9) The alkaline soils generally fixed a greater quantity of cation than the acid soils of the same class, but it was shown that the degree of fixation depended upon certain soil elements, chiefly calcium and magnesium in a condition to react with the neutral salt and not on the reaction of the soils. (10) Extracting the eight soils with HC1 and washing thoroughly greatly reduced the quantities of potassium fixed from KC1. (11) Potassium, calcium and magnesium were not fixed from neutral salts by the eight soils in equivalent quantities, showing that in each case fixation depended on different soil factors. (12) The fixation of potassium correlated with the exchange of calcium and magnesium; the fixation of calcium with exchange of magnesium; and the fixation of magnesium with exchange of calcium. (13) The reactions were reversible in all cases studied. (14) When the alkaline and acid sandy loam soils were saturated with certain cations at equal solution concentrations, then the fixation of the other cations used at the same concentrations was closely equivalent. These observations contain strong proof that the reactions involved are chemical in nature and that the cause of fixation by soils is the presence of soil elements, principally calcium and magnesium in a condition of reactivity, and the degree of fixation is independent upon both the kind and quality of reacting elements present.

In general the results of this investigation agree with the chemical hypothesis established by Way (9, 10). They also give a logical basis for the explanation of:

(1) Why the fixation capacities of soils of the same class often vary considerably, while the capacities of unlike classes may be similar. (2) Why a soil exhibits a certain degree of selection in this respect, that is, certain cations are fixed in greater quantities than others. (3) Why the order of fixation of several cations may vary in different soils. (4) Why mixture of neutral salts give varying effects on the same soil. (5) Why the degree of fixation correlates quite closely with the general fertility condition of soils. (6) Why leaching soils with acids decreases the quantity of fixation. (7) Why liming the soil increases the quantity of fixation. (8) Why the anions of neutral salts that form soluble compounds with calcium or magnesium are not fixed by soils, and (9) why the anions or acid radicals of salts that form insoluble compounds with soil calcium or magnesium are fixed by soils—phenomena observed by many soil investigators.

A prominent feature of this research was that very small quantities of potassium or sodium were found in soil solutions from untreated soils examined for these elements. The natural conclusion from these results was that these elements do not occur in appreciable quantities in replaceable combinations in the soils studied. Granting this conclusion to be true, a possible explanation may be given on the bais of the differences in solubilities of the carbonates of the alkali earth elements. Hydration and carbonation

are important soil processes and the carbonates of potassium and sodium resulting from these processes being much more soluble than the carbonates of calcium and magnesium similarly formed, may be leached from the surface section of soils to a much greater extent; the general effect would then be an indirect replacement of potassium and sodium in silicate combination with calcium and magnesium, and after sufficient time had elapsed only small quantities of potassium or sodium could be expected to be present in hydrolyzing combinations, while calcium and magnesium would probably be present for a considerable period of time in a hydrolyzable state after the original potassium and sodium of similar combinations had practically disappeared. Much evidence supporting this conclusion may be found in the literature concerning researches on soils and minerals. Further elaboration of the subject is not desired in this paper.

The elements potassium and sodium, then, must be in a much less soluble state in many surface soils than calcium or magnesium; and if their compounds do not hydrolyze, they undoubtedly occupy a different position in the molecular structure of their compounds than do calcium or magnesium, at least the portions of these elements that split off from their compounds as hydroxides and may easily be carbonated. If potassium or sodium are fixed in soils from chemical compounds, however, they probably occupy the same position of molecular structure as the elements they release because they may in turn be replaced in quantity by cations of other salts. These relationships should be of great scientific and practical significance.

The situation with respect to iron and aluminum of the soils was probably similar in some respects at least to that of potassium and sodium in that the evidence at hand points to the conclusion that they were not exchanged in quantity for the other elements fixed. The main points of evidence in this connection were as follows: (1) Except in two cases the solutions were alkaline to red litmus paper, hence acid salts of iron and aluminum combined with the anions of the neutral salts used in the treatments were probably not present. (2) Fixation and exchange were closely equivalent without considering the presence of iron or aluminum combined with anions of the salts used. (3) Iron and aluminum are present in the soils used generally in very much greater total quantities, and in the acid soils in much greater quantities soluble in 0.2 N HC1 than are calcium and magnesium, and providing exchange took place during the neutral salt treatments the accompanying phenomena would probably have been recognized. The conclusion seems justified that iron and aluminum were not present in the soils in exchangeable states, at least in any considerable quantities, but that they exist in the soils principally as hydroxides from the hydrolysis of soil minerals containing them or on the acid side of soil components as ferro-alumino-silicates. The soil component of non-carbonate soils reacting with neutral salts may then be a calcium-magnesium-ferro-alumino-silicate. These considerations refer to the mineral portions of the soils studied. The author does not assume that all soils contain no appreciable quantities of replacable potassium, sodium, iron or aluminum, but is of the opinion that the relative quantities of replaceable elements contained in soils is an individual characteristic. The possibility of secondary reactions should also be considered in this connection. In case of the KC1 treatments iron or aluminum chlorides may have been formed and neturalized again by the soils and the reaction not observed at the low concentration of neutral salts used; however, this reaction would not explain the iron and aluminum combinations in the soil solutions studied.

EFFECTS OF HYDROXIDES

Soil investigators have known for a long time that soils neutralize soluble hydroxides. This property of soils is generally considered due to hydrated silica of ferro-alumino-silicates. In order to determine if fixation from hydroxides followed the same general order as fixation from neutral salts the investigation was continued using KOH and $Ca(OH)_2$. Results from this work are given in Tables 7 and 8.

The alkaline soils fixed more potassium from the KOH solution than the acid soils of corresponding classes, except the alkaline clay loam, and more calcium from the more concentracted solution of $Ca(OH)_2$ except the alkaline medium sand which contains applied $CaCO_3$. The acid clay loam showed the same characteristics as in case of the neutral salt treatments in that it fixed more potassium and less calcium than the alkaline clay loam. Solutions from the KOH and concentrated $Ca(OH)_2$ treatments were alkaline to phenolphthalein showing an excess of hydroxide. Solutions from the less concentrated $Ca(OH)_2$ treatments were acid to phenolphthalein and in this case the magnitude of fixation in all the soils varied only slightly. Solutions from the KOH treated soils were characterized by comparatively large quantities of iron and aluminum (neglecting phosphorous) and SiO_2 but small quantities of calcium. Potassium was fixed in large quantities but no equivalent liberations were found in the solutions. Quantities of calcium found in the solutions from KOH treatments were very much smaller than the solubility factor for this element as $Ca(OH)_2$. Evidently potassium was fixed from KOH without exchange of calcium or magnesium and in addition the KOH dissolved iron, aluminum and SiO_2 from the soils.

That potassium fixed from KOH may be liberated again by neutral salts and $Ca(OH)_2$ treatments may be seen from the results presented in Table 8. The soils used in this case were first treated with the KOH solution, washed thoroughly with distilled water until the washings were neutral to litmus paper and then again treated with the $CaCl_2$ and $Ca(OH)_2$ solutions in the usual manner. The quantities of calcium fixed from $CaCl_2$ and quantities of potassium exchanged were closely equivalent, the equivalent factor being 0.512. Fixation of calcium from $Ca(OH)_2$ and exchange of potassium were proportional in the two soils studied, but not equivalent; a much greater equivalent weight of calcium was fixed.

Conclusions from the work on hydroxides are: (1) Potassium and calcium were fixed from their hydroxides in large quantities by soils without equivalent exchange of other elements. (2) The solubility effects of hydroxides on soils were of relatively great magnitude. (3) All of the soils used fixed the cations of the hydroxides. (4) A portion, at least, of the cations fixed from the hydroxides was in an exchangeable condition.

TABLE 7.—*Fixation of potassium from KOH and calcium from $Ca(OH)_2$.*

Potassium added 0.3910 gm.
Calcium added (a) 0.0455 gm.
Calcium added (b) 0.1069 gm.

Soil and reaction.	KOH treatments.				$Ca(OH)_2$ treatments.	
	Potassium.	Fe and Al oxides in solution.	SiO_2 in solution.	Calcium in solution.	Calcium fixed (a).	Calcium fixed (b).
M. S. al	0.1336	0.0305	0.0070	0.005	0.0346	0.0673
M. S. ac	0.1226	0.0865	0.0075	0.004	0.0386	0.0792
S. L. al	0.2249	0.0430	0.0365	0.007	0.0376	0.0871
S. L. ac	0.0931	0.0255	0.0245	0.004	0.0356	0.0792
St. L. al	0.2560	0.0385	0.0105	0.005	0.0336	0.0893
St. L. ac	0.1866	0.0130	0.0115	0.007	0.0356	0.0811
C. L. al	0.2725	0.0095	0.0080	0.007	0.0306	0.0831
C. L. ac	0.3020	0.0140	0.0095	0.006	0.0356	0.0792

TABLE 8.—*Soils treated with KOH, washed, then treated with $CaCl_2$ or $Ca(OH)_2$.*

Calcium added as $CaCl_2$ 0.1703 gm. as $Ca(OH)_2$ 0.1069 gm.

Soil and reaction.	$CaCl_2$		$Ca(OH)_2$		Wt. calcium
	Calcium fixed.	Potassium in solution.	Calcium fixed.	Potassium in solution.	Wt. potassium.
M. S. al	0.0258	0.0532			0.485
M. S. ac	0.0277	0.0561			0.494
S. L. al			0.1010	0.0640	1.578
S. L. ac			0.0891	0.0571	1.561
C. L. al	0.0673	0.1296			0.519
C. S. ac	0.0733	0.1508			0.486

EFFECT OF HYDROLIZING SALTS

Results of K_3PO_4 and $Ca(H_2PO_4)_2\ H_2O$ Treatments

In a foregoing section of this report is contained a discussion of the effects of neutral salts on alkaline and acid soils. Neutral salts, at least those used in this research, dissociate into ions and their principal effects have been noted. Another class of salts containing members often used in soil treatments have molecular dissociation as a distinct chemical property. A study of the reactions between some of these salts and the series of soils previously used was undertaken with results as shown in the following table. Table 9 contains results obtained from treating the soils with K_3PO_4 and $Ca(H_2PO_4)_2$ H_2O.

Table 9.—*Fixation from K_3PO_4 and $Ca(H_2PO_4)_2\ H_2O$.*

Potassium added 0.391 gm. PO_4 added 0.3168 gm.
Calcium added 0.3695 gm. PO_4 added 1.7223 gm.

Soil and reaction.	K_3PO_4				$Ca(H_2PO_4)_2$.	
	Potassium fixed.	PO_4 fixed.	Calcium in solution.	PO_4 fixed after treating with HC1.	Calcium fixed.	PO_4 fixed.
M. S. al......	0.1297	0.1136	trace	0.1062	—0.0222	0.0291
M. S. ac......	0.1087	0.1070	trace	0.1021	0.0021	0.0043
S. L. al......	0.2237	0.1623	trace	0.1145	0.0041	0.1013
S. L. ac......	0.1320	0.1475	trace	0.1103	0.0021	0.0559
St. L. al......	0.2618	0.2334	trace	0.1176	0.0122	0.0415
St. L. ac......	0.2229	0.1855	trace	0.1279	0.0082	0.0889
C. L. al......	0.2702	0.1979	0.0107	0.1496	0.0346	0.0869
C. L. ac......	0.2840	0.1838	0.0117	0.1269	0.0224	0.0498

Both members of each salt were fixed by the soils but not in chemically equivalent quantities. The magnitude and order of the calcium fixation did not differ materially from that determined in some of the preceding experiments with other calcium salts. The fixation of potassium, however, was considerably increased, but this quantity fixed was greater in case of the alkaline soils except the alkaline clay loam. Evidently the soil factors that determined the degree of fixation of potassium and calcium ions from neutral salts and hydroxides were operating also in the experiment under consideration. After treating the soils with HC1 and washing with distilled water in the same manner as was previously described the fixation of PO_4 was reduced but comparatively large quantities of PO_4 were fixed. The medium sand soils, acid sandy loam and silt loam fixed a greater equivalent of PO_4 than potassium. On the other hand, the alkaline sandy loam and the clay loam soils fixed greater equivalents of potassium than PO_4. Quantities of calcium liberated by the K_3PO_4 treatments were very small except in case of the clay loam soils.

The alkaline soils, except the medium sand, fixed more calcium from $Ca(H_2PO_4)_2$ than the acid soils of similar classes. Irregularities were also apparent between the fixation of calcium and PO_4 but these irregularities are not consistent with those observed with the K_3PO_4 treatments A greater quantity of PO_4 was used in the $Ca(H_2PO_4)_2$ treatments and may have changed conditions to some extent. The above stated results, however, point strongly to the conclusion that fixation of PO_4 in the experiment was not dependent upon the same soil factors as fixation of potassium or calcium and was independent of the quantities of potassium or calcium fixed, as shown by the unsatisfied equivalents. The phosphates form insoluble salts with calcium and magnesium, however, and are fixed by soils.

Results From $Ca(C_2H_3O_2)_2$ and $KC_2H_3O_2$ Treatments

Fixation from calcium and potassium acetates was next studied. The effects of $Ca(C_2H_3O_2)$ were desired and $KC_2H_3O_2$ was compared with the calcium compound because it is a salt of the same class. Results are given in Table 10.

TABLE 10.—*Fixation from $Ca(C_2H_3O_2)_2$ and $KC_2H_3O_2$.*
Calcium added 0.466 gm. Potassium added 0.3981 gm.

Soil and reaction.	$Ca(C_2H_3O_2)_2$.			$KC_2H_3O_2$.			
	Calcium fixed.	Magnesium in solut'n.	Acidity of solution in c. c. 0.1 N KOH	Potassium fixed.	Calcium in solut'n.	Magnesium in solut'n.	Acidity of solution in c. c. 0.1 N KOH.
M. S. al.	0.006	0.0044	1.2	0.0926	0.047	0.0042	1.4
M. S. ac.	....	0.0041	7.1	0.0629	0.007	0.0040	9.2
S. L. al.	0.014	0.0067	8.3	0.1443	0.036	0.0068	5.1
S. L. ac.	0.004	0.0046	6.1	0.1078	0.014	0.0042	11.3
St. L. al.	0.028	0.0118	6.1	0.1613	0.041	0.0123	7.2
St. L. ac.	0.012	0.0075	7.2	0.1506	0.035	0.0066	8.4
C. L. al.	0.030	0.0171	4.0	0.2061	0.069	0.0187	3.3
C. L. ac.	0.014	0.0135	8.1	0.2030	0.061	0.0133	4.6

Excepting calcium fixed by the medium sands, the alkaline soils fixed more calcium and potassium and liberated more calcium and magnesium than the corresponding members of each class. The exchange, however, was not in equivalent proportions thereby agreeing with results from the phosphate treatments. Quantities of calcium and magnesium found in the extracts agreed favorably with those found in the case of the neutral salt treatments, particularly KCl. Evidently calcium and potassium were fixed and an equilibrium set up between certain soil elements and the acetate ion, the acetates formed being soluble in water. It may also be observed from results given in Table 10 that the KOH titration on the soil extracts with phenolphthalein as indicator was not a measure of the calcium or potassium fixed by the soils, but an approximate measure of conditions in the extract; i. e. the closer the equivalent of acetate-ion to potassium fixed by the soils, or acetate-ion set free, agree to those of calcium and magnesium found in the extracts less KOH is required to neutralize the extracts. This relationship is not so apparent in case of the $Ca(C_2H_3O_2)_2$ treatments. While these results are not definite they may be considered as indications of the true state of affairs in this connection.

Results Obtained from Treating the Soils with $K_2C_2O_4$ and $FeCl_3$

TABLE 11.—*Fixation from $K_2C_2O_4$ and $FeCl_3$.*
Potassium added 0.3910 gm. C_2O_4 added 0.44 gm.
Iron added 0.3910 gm. (as Fe_2O_3)

Soil and reaction.	$K_2C_2O_4$		$FeCl_3$.			KCl after washing.		
	Potassium fixed.	C_2O_4 fixed.	Fe_2O_3 fixed.	Calcium in solution.	Calcium in solut'n Fe_2O_3 in soil.	Potassium fixed.	Calcium in solution.	Magnesium in solution.
M. S. al.....	0.0928	0.1258	0.1170	0.1502	1.284	....	....	....
M. S. ac.....	0.0678	0.0308	0.0330	0.0244	0.729	....	....	....
S. L. al.....	0.2308	0.1804	0.1990	0.1543	0.775	0.0405	0.033	0.0040
S. L. ac.....	0.1306	0.0616	0.0570	0.0406	0.712	0.0019	0.006	0.0027
St. L. al.....	0.2434	0.1980	0.1600	0.1177	0.736	....	....	....
St. L. ac	0.2092	0.1496	0.1390	0.0974	0.701	....	....	....
C. L. al.....	0.2580	0.2640	0.2910	0.2152	0.740	....	....	....
C. L. ac.....	0.2879	0.2772	0.3130	0.2192	0.700	....	....	....

In case of the $K_2C_2O_4$ treatments, Table 11, the results agree generally with those obtained from K_3PO_4 and $KC_2H_3O_2$ with respect to order and quantities of potassium fixed. C_2O_4-ions fixed were not equivalent in amounts to the potassium ions fixed. Calcium was found to be present only in traces in these extracts.

$FeCl_3$ was used as an example of an acid hydrolyzing salt and the quantity of iron fixed was found closely proportional to the calcium found in the extracts, except in case of the alkaline medium sand soil which contains limestone in considerable quantities. Magnesium was not determined but probably enters into the reaction. The extracts from these treatments were acid and the effects, in general seem to have been a neutralization of the acid salt. In this experiment an attempt was made to determine if the iron fixed in the sandy loam soils could be replaced by a KCl treatment after washing the $FeCl_3$ treated soils with water. Results of these determinations are given in the portion of Table 11 headed "KCl after washing". It may be observed that the potassium fixation was greatly reduced as compared with the results from fixation of potassium from KCl in the untreated soils, an equal quantity of KCl being used in the solutions. Also, calcium and magnesium found in the solutions were more than equivalent in quantities to the potassium fixed. From these considerations it is doubtful if the iron fixed from the $FeCl_3$ treatments may be replaced and probably exists in the soils in the hydroxide form. The effect of lowering the potassium fixation was similar to that produced by HCl.

Effects produced by treating soils with hydrolyzing salts are similar in some respects to those obtained by treating with neutral salts and dissimilar in other respects. The alkaline soils with few exceptions fixed a greater quantity of the basic radicals of all the salts used as well as the acid radicals that form insoluble compounds with calcium or magnesium. An explanation of the exceptions was given in case of the neutral salts treatments. The same explanation may apply to the exceptions noted in the hydrolyzing salts treatments. The acid clay loam soil fixed more potassium and less

calcium than the other member of its class, and liberates more calcium but less magnesium. The fixation of potassium from $KC_2H_3O_2$ by the clay loam soils does not agree with the above explanation although the results are in close agreement. The acid silt loam fixed more PO_4 from $Ca(H_2PO_4)_2$ than did the alkaline silt loam. The effects of the presence of $CaCO_3$ in the alkaline medium sand was also noticeable in case of the calcium salts and $FeCl_3$ treatments. The dissimilar effects noted between hydrolyzing and neutral salts treatments were a much greater quantity of potassium fixed from the hydrolyzing salts, and the absence of chemical equivalents between elements fixed and those found in the soil solutions. The hydrolyzing salts used may be placed into three separate classes based on their effects upon the soils; namely, alkaline salts, acid salts and salts forming insoluble compounds between their acid radicals and soil elements. A fourth class may be considered in cases where an acid radical of an acid hydrolyzing salt would form an insoluble compound with soil elements.

A brief summary of observed effects of the hydrolyzing salts treatments follows: (1) The alkaline soils, with few exceptions, fixed a greater quantity of cations from hydrolyzing salts than the acid soils of the same classes. (2) Greater quantities of cations were fixed from hydrolyzing salts than from neutral salts. (3) Closely equivalent exchanges of soil elements for those fixed from hydrolyzing salts were not observed, however, the fixation of iron from $FeCl_3$ was nearly proportional to the calcium found in the soil solutions except in case of the limed soil. (4) Exchange of soil elements was observed in cases where these elements formed soluble compounds with the anions of the salts used. (5) Fixation of one ion of a hydrolyzing alkaline salt was apparently independent of the fixation or combination of the others.

GENERAL SUMMARY

Data accumulated in this research point strongly to the conclusion that when neutral salts, hydrolyzing salts or hydroxides in solution are placed in contact with soils a chemical reaction results in which portions of the cations or basic radicals of the added compounds are precipitated in the soil mass and in case the anions or acid radicals of the salts used form soluble compounds with calcium or magnesium the resulting salts are found in the soil solution. When the acid radicals of added salts form insoluble compounds with calcium or magnesium they were also precipitated in the soil. Fixation or precipitation of potassium, sodium and ammonia ions from neutral salts was shown to be dependent chiefly upon the calcium and magnesium of the soils, while the fixation of calcium depended upon soil magnesium and fixation of magnesium upon soil calcium. The several classes of components used in treating the soils, however, showed different effects. With few exceptions the alkaline soils fixed greater quantities of the members of the salts fixed than the acid soils of the corresponding classes.

The reaction between neutral salts and soils appeared to be less complicated than in case of any of the other classes of compounds used. A portion of the cations of the salts used was precipitated in the soil mass and a nearly equivalent quantity of certain soil elements, or a soil element depending upon the salt used, combined with the anion of the salt was found in the resulting solutions. The cations precipitated or fixed were replaced by dissimilar cations of neutral salts which were also fixed in the soils.

Cations of the bases used were probably fixed in the soils without exchange of soil elements, because the quantities of calcium found in the solutions from

KOH treatments were much smaller in magnitude than the solubility factor of calcium as $Ca(OH)_2$ and magnesium was not found in sufficient quantities in any of the extracts from either the KOH or $Ca(OH)_2$ treatments to alter the above conclusion. Providing $Ca(OH)_2$ was formed by the KOH treatments the presence of a greater quantity of calcium should be expected in the extracts. On the other hand potassium fixed from KOH was apparently liberated by the $Ca(OH)_2$ treatments. The solubilities of the hydroxides in question is probably a most important consideration. Potassium fixed from KOH was liberated again by treating with $CaCl_2$.

In summarizing the effects of hydrolyzing or molecular dissociating salts attention must be given to the different classes involved. In case of the $KC_2H_3O_2$ treatments there was evidence of exchange between the potassium of the salt and calcium and magnesium of the soils thereby agreeing in this respect with results from the neutral salt treatments. Much greater quantities of potassium were fixed, however, and the extracts were over balanced with $C_2H_3O_2$ ions as shown by the titrations with 0.1 N KOH solution. The acetate acted similarly to a neutral salt and hydroxide combined giving uncombined $C_2H_3O_2$ ions in the soil solutions, but the uncombined $C_2H_3O_2$ ions were not a measure of the quantity of potassium fixed by the soils. Effects produced by $Ca(C_2H_3O_2)_2$ were probably similar to those obtained by the $KC_2H_3O_2$ treatments. K_3PO_4 may be considered representative of another class of hydrolyzing salts, both members of which were fixed by the soils. As shown by lack of chemical equivalents in the case studied, different soil factors were probably responsible for the fixation of potassium in PO_4 ions. It was apparent, however, that these factors were closely related to the calcium and magnesium content of the soils. Either calcium and magnesium were responsible or some other factor or factors closely allied with these elements, because in nearly all cases the alkaline soils fixed a greater quantity of K_3PO_4 than the acid soils of the same class. Some soils fixed a greater equivalent of potassium ion than PO_4-ion, and in the other soils this order was reversed. Whether the potassium ion or PO_4-ion is fixed in greater quantity seems to depend upon the quantity relationships of the soil factors involved. Effects of $Ca(H_2PO_4)_2$ and $K_2C_2O_4$ were similar to those of K_3PO_4, except magnesium was present in extracts from the $K_2C_2O_4$ treatments, although the quantity was not determined, and this element was probably in the form of MgC_2O_4. Although undetermined, these reactions are probably reversible because reactions between neutral salts and soils and KOH and soils are reversible at least with respect to their basic ions. $FeCl_3$ belongs to a third class of hydrolyzing salts being acid in reaction. From effects of this salt upon the soils it is believed that the iron was precipitated in the soil mass as the hydroxide and that the reaction is not reversible. In general the effect of this salt upon the soils compared to the effects produced by treating the soils with HCl.

From the results of this investigation it is believed that only small quantities, if any, of potassium, sodium, iron or aluminum were present in the soils used in an exchangeable condition. This point was discussed more fully in connection with the summary of the experiments with soils and neutral salts.

Data presented favor the conclusion that the reaction between soils and the chemical compounds used is chemical in nature rather than physical. The main lines of evidence bearing on this point have already been discussed, and they are principally the relationships shown between fixation and the calcium and magnesium of the soils or other elements fixed in the soils by

chemical treatments. The magnitude of fixation evidently depends upon the nature of the chemical compound used in treating the soils; its manner of dissociation, the solubility of the resulting products, and the quantity relationship between the reacting components. As the foregoing factors vary different chemical systems would be set up between the reacting materials. Providing the reactions under consideration are chemical, chemical laws and theories should be applicable. It must be remembered, however, that soils are very hetrogeneous substances and they cannot be expected to submit to manipulation as might be the case with chemically pure substances. Many difficulties stand in the way of a clear interpretation of results. We know as yet very little concerning the chemical constitution of the soil. Very little is known concerning the effects of added salts on the solubilities of soil components, the possibility of the formation of double salts, the effect of reaction of soil media upon solubilities, and the possibility of secondary reactions. Further work along intensive lines is necessary before a complete understanding of the relationships involved can be obtained.

A law of reaction between chemicals and soils may then be formulated from the foregoing results and conclusions. An ion of any soluble salt that forms an insoluble compound with soil components will be fixed in soils from solutions of the salt, and if soluble combinations are formed during the reaction they will appear in the soil solution or extract. When salts that dissociate into ions are placed in contact with wet soils the fixation of the cations depends upon the resulting combination of the anions; i. e. fixation and liberation of elements are equivalent; and when alkaline salts that dissociate into molecules are placed in contact with wet soils fixation from one molecule is independent of the fixation from or combination of the others. This law may be stated more specifically when the class of the dissociating compound is known. In general fixation and liberation of elements, under the foregoing conditions, depends upon the manner of dissociation of the chemicals used in soil treatments and the solubilities of the compounds formed, and the magnitude of fixation depends upon the quantity relationships between the reacting components. The power of a soil to fix cations may be increased by bringing it into contact with hydroxides or alkaline salts in solution, and decreased by acid and acid salt treatments; but neutral salts very in their effects on this soil characteristic, causing either no equivalent change or an increase depending upon the elements involved.

THE SOIL REACTION

Results obtained in this investigation may be interpreted as to give a better understanding of the phenomena of soil reactions particularly with respect to the mineral portion of the soil. Basing conclusions on these results it may be said that practically all soils have acid and basic properties in common because they neutralize acids and also alkalies. In general, all soils decompose neutral and hydrolizing salts, at least the common salts of these classes. A general similarity in these respects exists between acid and alkaline soils. (Litmus paper test.) The differences noted were in magnitude only, and these differences in magnitude were practically all in favor of the alkaline soils over acid soils of similar classes. From a quantity standpoint, however, certain acid soils may show a greater magnitude of reaction with chemical compounds than certain other alkaline soils, because the degree of change depends upon the quantity relationships. Therefore,

the decomposition of neutral salts, hydrolizing salts or fixation of hydroxides is not a distinguishing property of acid soils, and this being the case it is difficult to understand the basis of the present use of these chemical compounds, except possibly soluble hydroxides under conditions of neutral equilibria, for qualitative or quantitative determinations of soil acidity or for lime requirement determinations. In fact, the results of this investigation show that the factors causing fixation from neutral salts and those concerned with soil acidity are diametrically opposed. The case of treating soils with $KC_2H_3O_2$ and $Ca(C_2H_3O_2)_2$ has already been discussed. The quantities of uncombined $C_2H_3O_2$-ions found in the soil extracts were not a measure of the quantities of potassium or calcium fixed by the soils from these salts; but in case of the $KC_2H_3O_2$ treatments the quantities of $C_2H_3O_2$-ions found in the soil extracts were an approximate measure of the differences between quantities of potassium fixed and calcium magnesium found in the solutions. Applying the same reasoning to the $Ca(C_2H_3O_2)_2$ treatments the quantities of $C_2H_3O_2$-ions found in the soil extracts would be roughly proportional to the differences between quantities of calcium fixed by the soils and magnesium occurring in the solutions. Replacing a soil element with another element from a salt gives no means of measuring the magnitude of soil acidity. Another important point in this connection is because of the complicity of the reactions involved, the titration of soil extracts with either acids or alkalies will be attended by difficulties unless the chemical composition of the extracts is known. Apparently the reaction of a soil is determined by quantity relationships, not the relationships existing between the water soluble soil material or the solubility products of soil components, but between the quantities of the active masses of the components involved. In other words, all soils may contain reserve alkalinity and reserve acidity and the soil reaction may be the result of mass action between the active masses of these components. The term active mass referring in this connection to all the material which could be brought in a condition to react. A neutral soil then, would represent a case where the active masses of reserve alkalinity and reserve acidity were equivalent, and soils containing un-equivalent active masses of these components would be either acid or alkaline as the case might be.

Practical Considerations

The statement has been made that the magnitude of fixation in soils is closely related to their agricultural value, the soils fixing the greatest quantity of substances being the best for agricultural purposes. Since it has been shown that fixation from chemical salts depends chiefly upon the calcium and magnesium content of soils, it follows that the calcium and magnesium content of soils is an important fertility factor. The quantity of calcium and magnesium in itself, however, is probably not nearly as important from the fertility standpoint as is the ratio between the quantity of active calcium and magnesium and other soil materials, namely, acid silicates; because alkaline soils as a class are usually more fertile than acid soils and alkaline soils have greater ratios of calcium and magnesium to acid silicates than acid soils. The agricultural value of a soil then probably depends to a certain extent upon its active quantity ratio of calcium and magnesium to acid silcates.

Liming increases fixation and thereby gives a soil a certain potential value enabling it to better conserve its fertility, as represented by the fertility products of soil processes or applied as fertilizers; to better prevent

unfavorable reactions with fertilizers and plant nutrients developed within the soil mass; to deliver nutrients to plants under more favorable conditions; and to provide a more congenial medium for the development of beneficial bacteria. By considering the transformations of the chemical compounds involved the applications of the foregoing statements will become apparent.

Some of the transformations and effects of fertilizer salts when added to soils may be anticipated from the results presented herein especially when the class of salt is known. Volumes may be written on this subject but only a short discussion of principles will be given here. Some of the effects of chemicals on soils are as follows: (1) An equivalent exchange may take place between the cation of a neutral salt and a soil element thereby enriching the soil solution with the resulting soluble compounds. (2) Any molecule of a hydrolyzing salt may appear in the soil solution after treatments with this class of salt. (3) Hydroxides may be partially or wholly fixed in the soil depending upon the solution concentration. (4) Acid salts may act similarly to acids and leave insoluble hydroxides in the soil. (5) The general effect depends upon kind and quantity of reacting materials. Therefore, from a chemical standpoint the proper fertilization of each soil is an individual proposition and one that requires careful study if maximum benefits are to be obtained. The same line of reasoning applies to all soil experimental work where soils are treated with chemical compounds. In order to explain the results obtained it is necessary to know the chemical changes produced by the soil treatments. Much chemical experimental work has been done on soil classes or soil types as a basis; but there is a considerable variation in the chemical constitution of similar classes of soils, in fact, there may be greater differences in this respect between soils of the same class than between soils of different classes. In this investigation there is a marked similarity in the results from the alkaline sandy loam and acid silt loam soils and the alkaline medium sand and acid sandy loam soils; while the results from similar classes vary considerably except in case of the clay loam soils. It is evident that soil types or classes based on physical properties provide no consistent basis for chemical investigations designed to study the effects of chemical compounds on biological growths or soil processes.

A common criticism of field experimental work with fertilizers from a scientific standpoint is that results obtained can not always be explained. An apparent reason for this situation is that the effects produced on the soils by the applied fertilizers are not known. Whatever may be said in this connection, it is certain that when soil investigators pay more attention to the chemical nature of the soils under investigation the science and practice of soil management will be greatly benefited thereby.

CONDENSED SUMMARY

Data are presented in this publication showing the general effects of applications of neutral salts, hydroxides and hydrolyzing salts to acid and alkaline soils (litmus paper test) of several classes. The experimental procedure consisted in bringing together 100 gm. of air dried soil and 500 c.c. of salt solution for a period of one hour, filtering through paper and analyzing the resulting solution. Results are briefly summarized as follows:

1. When solutions of neutral salts were placed in contact with the soils used the cations of the salts were fixed in the soils and closely equivalent quantities of calcium and magnesium or other elements previously fixed in the soils by chemical treatments were found in the resulting solutions.

2. When solutions of alkaline salts were used to treat the soils fixation of one ion was independent of the fixation or combination of the other.

3. Iron was fixed in the soils from $FeCl_3$, and acid salt, and a closely proportional quantity of calcium liberated except in case of a soil containing limestone.

4. Anions or acid radicals of the salts used that form insoluble compounds with calcium or magnesium were fixed by the soils and similar components that form soluble compounds with these soil elements were not fixed by the soils.

5. Potassium and calcium were fixed from their hydroxides, but no evidence of exchange of soil elements was observed.

6. In case of the neutral salt treatments the fixation of potassium correlated with the liberation of calcium and magnesium and in one series of non-carbonate soils a relationship was observed between fixation of potassium and quantities of calcium and SiO_2 dissolved by 0.2 N HCl. The fixation of magnesium correlated with exchange of calcium and fixation of calcium with exchange of magnesium.

7. The fixation of an element was reversed by neutral salts containing other elements in all cases studied except the $FeCl_3$ treatments.

8. Potassium, calcium and magnesium were fixed by natural soils in unequivalent quantities, but when soil calcium and magnesium were largely replaced by a single element, potassium, sodium or magnesium, then the fixation of the first named elements became closely equivalent.

9. Soils fixed much greater quantities of calcium from $CaCl_2$ after being treated with $MgCl_2$ than they did before the treatment.

10. With few exceptions fixation was greater in quantity in alkaline soils than in acid soils of the same class.

11. Fixation from neutral salts was probably due to a calcium-magnesium-ferro-alumino-silicate; of hydroxides to acid silicates, and from hydrolyzing salts due to a combination of these soil components.

12. Fixation from chemical salts and exchange of soil elements depends upon the manner of dissociation of the salt used for treatments and the solubilities of the compounds formed. The magnitude of fixation and exchange depends upon the quantity relationships between the reacting compounds.

13. The results of this investigation are in accord with the chemical hypothesis of Way (9, 10).

14. There was no evidence of replacement of potassium, sodium, iron or aluminum in any considerable quantity in the untreated soils studied.

15. Fixation from neutral salts, hydrolyzing salts or of hydroxides was not a distinguishing characteristic of the acid soils.

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SOME FACTORS IN SOIL FERTILITY.

INTRODUCTION.

Agriculture is a permanent industry and must exist as long as human society. Indeed it is the most important supporter of other industries and education. The betterment of agriculture is the foundation, the basis of all general prosperity. The fertility of the soil is the greatest of the natural resources.

Plants require food for their existence and growth and if the soil does not contain the required food elements or are infertile, life and growth are impossible. Better tillage and improved varieties of seed can not materially increase the production of infertile or depleted soils. In fact no factor of crop production under the control of man, influences the yield of crops to such an extent as the fertility of the soil.

Under adverse climatic conditions the crops on an infertile soil may fail completely while those on a fertile soil may yield fair returns. Thus in a season of drought the plants on fertile soil make a more economical use of the soil moisture and yield better than those on poor or infertile soils. Fertility also acts as a protective agent against many diseases of plants and it is very probable that a decrease in fertility accounts in no small degree for the common occurrence of some plant diseases and insect pests. This may be illustrated by the Hessian Fly on wheat during the season of 1920. Where phosphates were applied to the heavier soils in a number of our demonstrations according to counts made by C. W. Simpson, the injury by fly was much less. Moreover, where seeding is delayed because of this pest, the handicap may be largely overcome by the use of fertilizers.

In as much as the success and prosperity of a farmer depend largely upon the fertility of his soil it behooves every farmer and landowner to recognize and appreciate the importance of this basic factor of crop production. Thus they should direct their efforts towards the maintenance and increase of the fertility of their land.

Since the fertility of the soil is the greatest of the natural resources and is the most important supporter of all agriculture it follows that it is both desirable and obligatory on the part of national, state and county governments to do all that is practicable towards the maintenance or the increase of the fertility of the soil.

LOSS OF PLANT FOOD ELEMENTS FROM SOILS.

Popular Bulletin No. 290

BY M. M. MCCOOL, C. E. MILLAR, G. M. GRANTHAM, SOIL SECTION

Virgin soils in humid regions become less fertile with age. In various sections of the United States there are large areas of rather heavy lands which were in a very low state of fertility when first settled by the white man. These areas were once very productive but due to the various climatic factors operating through long periods of time they became depleted. It is evident therefore that there are certain natural agencies which tend to impoverish the soil. When soil is brought under cultivation usually these natural agencies are stimulated to a certain extent and new ones are also added. The most important of these are leaching, erosion and the removal by crops.

THE LIME PROBLEM IS GENERAL.

The amount of lime removed by leaching is greater than the amount of other substances lost in a similar manner. Tests conducted by farmers, county agents and members of the Soils Section show clearly that many of our lands have reached the stage where liming is advisable for satisfactory crop production, especially if one desires to grow the clovers, alfalfa and vetch. There are reasons for this condition. Lime is constantly removed from soils by leaching or washing by rain water that falls on them and by the crops that are harvested. The loss of lime from the soil is exemplified by the conditions that exist in many places in Michigan. When the better classes of our soils were left by the glacier they contained about the same amount of carbonate of lime from the surface downward. Of course the different kinds of soil varied from one to the other. Our soil surveys show that carbonates do not exist even in the fine textured soils over much of the State above thirty-six inches, although in some types it lies within eighteen inches of the surface, whereas in sandy soils it has been removed to depths ranging from four to ten or more feet. The marl beds bear witness of this removal from the upland soils and owe their existence to it. This means that sooner or later all soils will become deficient in this substance and must receive it in some form if they are to continue to be productive. Our investigations also show that not all of our soils are deficient in lime or respond to its application. It may be cited for example that the finer textured soils of the Old Lake Bed of eastern Michigan, the Thumb area and the Saginaw Basin are not in need of it. Aside from these and portions of the soils in Alpena, Presque Isle, Cheboygan, Emmet, Charlevoix, Antrim, Otsego, Grand Traverse and Leelanaw counties, the majority of the soils in the southern Peninsula are deficient in this element.

When it is considered that lime is necessary for soil productivity and that it is lost by leaching or washing and by removal of crops from the land the conclusion is logical that the use of it in some form is one of the necessary practices involved in permanent systems of agriculture.

THE NITROGEN PROBLEM IS ACUTE IN SOME SECTIONS.

Nitrogen is necessary for plant growth. The maintenance of ample amounts of active vegetable matter or humus in the soil to supply nitrogen to crops and to keep the soil in good condition constitutes our greatest soil problem. Therefore the nitrogen and humus problem needs special consideration.

Nitrogen is found in all plants, soil organic matter or humus as well as in several commercial forms. When present in or added to the soil in suitable compounds it results in an intensity of the green coloring matter, and increases the root, stem and leaf development or the vegetative portions of the common plants. On the other hand it is well-known that the presence of an excess of available nitrogen may prevent proper seed formation and cause loding of grains and grasses, especially if the phosphorus and potassium are somewhat deficient. The amount at the disposal of the crop affects greatly its quality in as much as large amounts result in the formation of soft tissue. Therefore, one may regulate somewhat the quality of such crops as cabbage, celery, lettuce, asparagus and others by controlling the nitrogen relationships. It is well to mention that excessive amounts prolong the growing period or delay maturity.

Nitrogen starvation is indicated by yellowish or pale-green colored leaves, lack of thriftiness or a general stunted appearance. It should be recalled that other soil conditions may result in similar symptoms.

Sources of Nitrogen. There are four *chief* sources of nitrogen for crops, namely from vegetable matter or humus, from bacteria in legumes, from bacteria and other forms in the soil and from commercial fertilizers. The chief source for most crops is the soil vegetable matter, commonly spoken of as humus.

Nitrogen from vegetable matter is important. Before this nitrogen is made use of or taken from the soil by the crops the process of decay or rotting and nitrification or the formation of nitrates must take place. Decay may be and usually is brought about by several kinds of organisms or germs which infest the soil. These processes or the making available the nitrogen of the humus may be slow under some conditions and rapid under others.

When the soil is cool or the temperature is low and it is wet, decay and consequently the rendering of the nitrogen available for crops is very slow. On the other hand when the soil is warm and moist, but not soaked with water, these processes are much more rapid. If lime is deficient in the soil its addition results in hastening decay. It has also been shown that phosphorus acts similarly and it is probable that the splendid effects of acid phosphate, late in the autumn and early in the spring, are due in part to this action.

The kind of material that is added to or is present in the soil governs the rate of formation of available nitrogen. It is well recognized that clovers, alfalfa, beans, peas and vetch decay more rapidly in the soil than do straws of the cereals. The breaking down of the latter may proceed very slowly if lime is deficient in the soil.

The rate of decay and consequently the formation of nitrates in the soil is most rapid near the surface. This may be illustrated by the conditions of fence posts that have been in the soil a number of years.

They usually rot off or are broken off at or near the surface of the ground, yet decay takes place at greater depths but to a much less extent depending upon the nature of the soil, that is, whether heavy or light as well as the water content. This is shown in Fig. 1, after Fippin. Decay takes place more rapidly in soils that are devoted to row or tilled crops than it does in those devoted to others. These processes proceed rapidly in fallow land or land not occupied by crops that is stirred frequently.

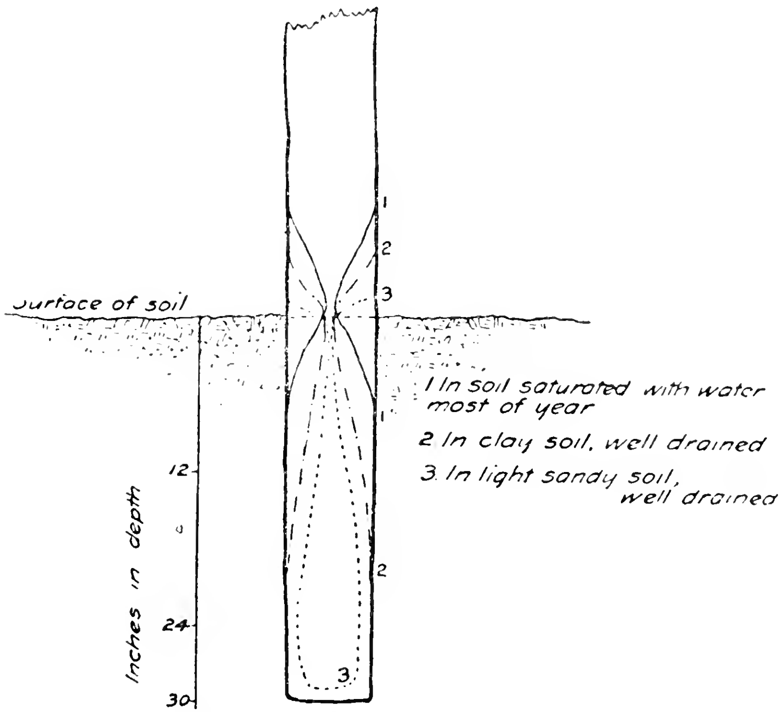


FIGURE 1.—The rate of decay of manure and crop residues is controlled by soil texture, moisture content and the depth of covering.

Decay should not be too rapid. If these processes take place too rapidly great losses of nitrogen may take place. This is true because nitrates are readily soluble in or are dissolved by water and thus if not utilized by growing plants they may be washed out of the soil and pass away in the drainage water. We have found for example that they move about quite readily with the soil moisture. Dr. T. L. Lyon of the New York Agricultural College at Cornell University found that heavy land unoccupied by a crop lost 444.8 pounds of nitrogen per acre by leaching, whereas the losses from the same soil when cropped were 25.6 pounds per acre per year.

We may say therefore that the presence of vegetable matter in the soil is essential to successful crop production because it is from this that plants obtain much of their nitrogen supply. Moreover there are other decidedly beneficial effects such as the improvement of soil tilth,

the making available of phosphorus, potassium and other elements of plant-food as well as the favorable effects it has on lower organisms, germs or bacteria that are beneficial. This material must decay in the soil, consequently if a proper supply is maintained provision must be made for regularly renewing it. This is another condition essential to soil fertility.

Nitrogen may be taken from the air by legumes. The soil does not furnish all of the nitrogen that some crops contain. The legumes or those plants that form seed in pods such as the clovers, alfalfa, peas, beans, cowpeas and vetch may obtain nitrogen from the soil air by means of germs or bacteria that are present in the soil or added to it. These attack the tender portions of the roots and cause galls, tubercles

FIGURE 2.—It is much better to have straw rot in the soil than in the pile or stack or to be burned.

or nodules to form. In these are large numbers of germs or bacteria which are able to take the nitrogen from the soil air and pass it on to the plant in such form that it makes use of it in its growth. In the light of our present knowledge we may say that such crops derive about two-thirds of their nitrogen from the soil air and one-third from the soil. This relationship is shown by figures 3 and 4.

Nitrogen may be fixed in the soil by other organisms. Some germs or organisms take nitrogen from the soil air and fix it or place it directly in the soil in such condition that it may be utilized by crops. This may proceed in the absence of growing crops. It is agreed that the activity of these varies greatly in different soils and they are encouraged by many conditions that are favorable to the common crops such as heat, moisture, lime, phosphorus, vegetable matter, good tilth and others.

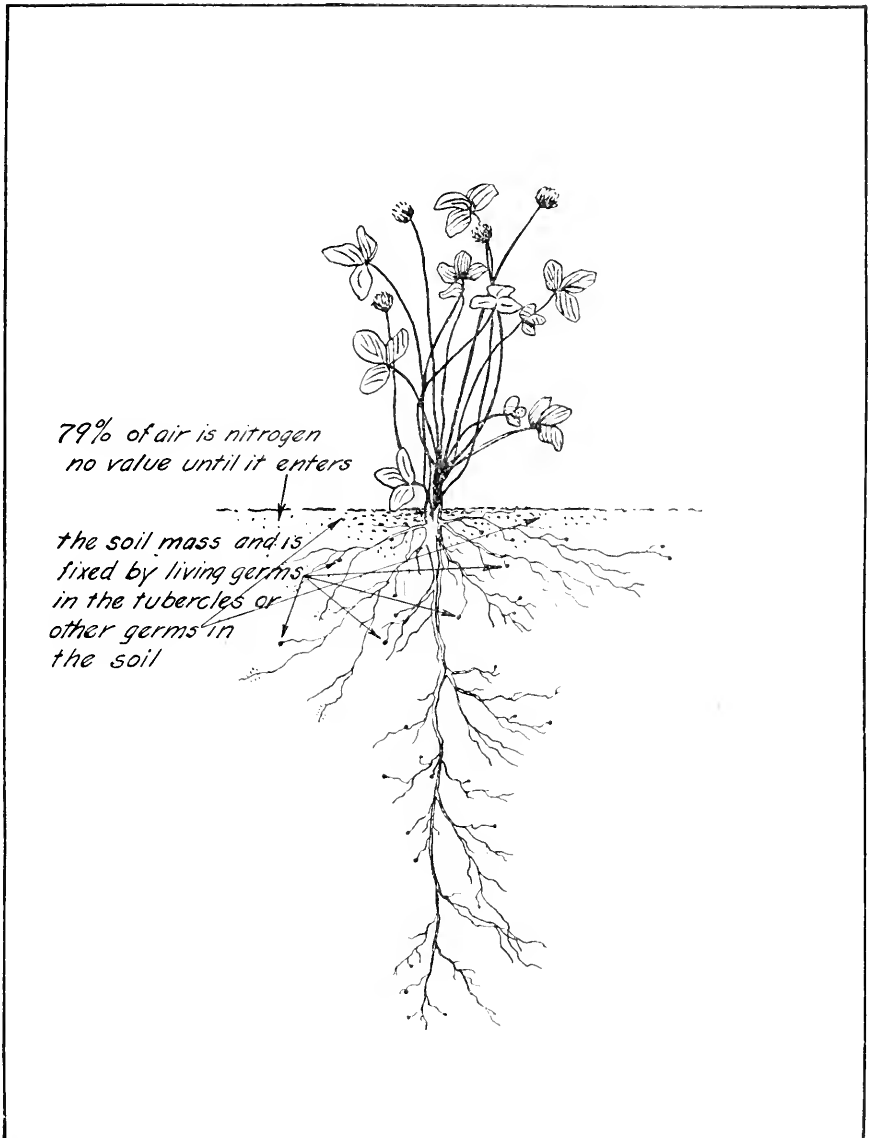


FIGURE 3.—The cheapest source of nitrogen is the air. More legumes should be grown in Michigan.

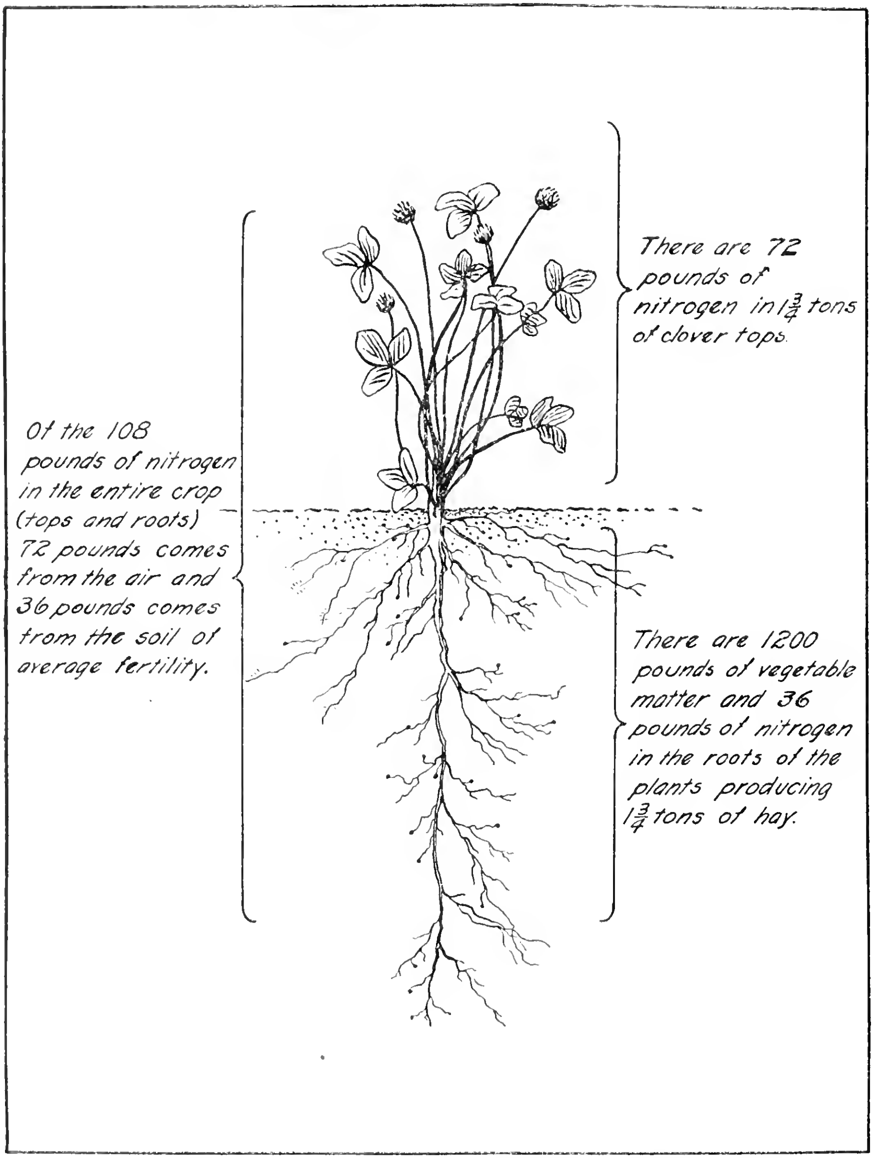


FIGURE 4.—The supply of nitrogen in the soil is not increased by growing clover if all the hay is removed.

THE POTASH SITUATION DESERVES CONSIDERATION.

Potash is leached from the soil in relatively small amounts. Analyses of river, well and drainage waters taken from several parts of the humid areas of the world show that this is not important in the maintenance of soil fertility. When this element of plant-food is applied to the soil it is held quite firmly until removed by growing plants. Very porous sands may be exceptional however. On the other hand potash that is present in hay, straw or manure is quite easily washed out when exposed to the elements and may be lost so far as crop production is concerned.

Potash is contained in relatively large amounts in unleached manure, one ton on the average carrying 10.5 pounds. This constitutes the chief carrier of potash used on Michigan soils. Potash can be purchased on the market in several carriers.

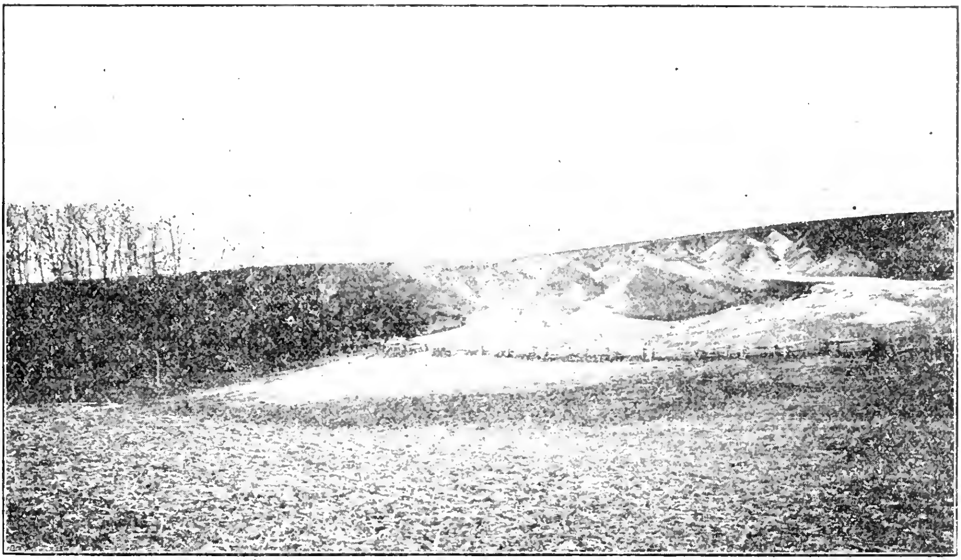


FIGURE 5.—Gullying in fields makes portions of them inaccessible, unproductive and buries good land that lies at lower levels.

THE LOSSES OF PHOSPHORIC ACID BY LEACHING ARE SMALL.

The amount of phosphoric acid removed from soils by drainage water is less than that of potash. Investigations conducted in England and at several experiment stations in this country show that phosphoric acid that is present in or added to soils is held tenaciously by them. Moreover it is not removed from manure or crop residues as is potash.

Manure contains less phosphoric acid than potash, a ton carrying under average conditions about 6 pounds. The chief sources of supply are the commercial carriers.

Most soils of the State respond to applications of phosphate fertilizers. For further information relative to this important plant-food refer to

the Michigan Experiment Station regular bulletin No. 284—"Some Information and Suggestions Concerning the Use of Phosphorus."

SOIL EROSION SHOULD BE CHECKED.

The removal of the surface soil by water erosion or washing is serious in many fields. The gullying in fields attracts some comment and results in considerable inconvenience in certain localities but on the whole this is of minor importance in comparison with sheet erosion or the displacement of the surface layer of soil without the formation of gullies. The fertility of small valleys and depressions and the low productivity of knolls and ridges in undulating and rolling land bear evidence of the washing from the upland of the richer surface soil. Moreover soluble plant-food constituents accumulate to a variable extent on the surface of these heavier soils as they become dry, more so when either bare of vegetation or devoted to tilled crops than if occupied by grasses or small grains. When torrential or dashing rains follow such conditions appreciable quantities of these are removed by the water that runs off the surface.

These amounts do not seem large and yet when it is recalled that they must be procured from the available supply of the soil they assume a

FIGURE 6.—Sheet erosion accounts for the low productivity of many rolling or hilly lands because it removes the fertile surface soil.

new importance. A large number of samples have been taken from the predominating soils types in Michigan and subjected to analyses. The samples were placed in two groups: cropped and uncropped. The former were taken from fields which have been under cultivation for a long period of years and the other group from line fences, woodlots and virgin timber, which have never been under cultivation. A summary of the results of many analyses is given in table 1.

TABLE 1.—Pounds of nitrogen, phosphoric acid and humus in cultivated and uncultivated soils.

	Nitrogen.			Phosphoric acid.			Humus.		
	Virgin.	Cropped.	Per cent difference.	Virgin.	Cropped.	Per cent difference.	Virgin.	Cropped.	Per cent difference.
Level to undulating loamy sands and sandy loam of S. W. Michigan—original timber largely oak	3,032	1,993	34.27	2,471	2,086	15.57	63,672	41,853	34.27
Level to undulating loams of S. W. Michigan—original timber oak, maple, beech, some hickory	4,562	3,355	24.46	3,154	2,224	29.48	95,802	70,455	24.46

The decreased fertility shown in this table is supported by observations of the older settlers, who in many communities tell us of the large wheat yields and luxuriant stands of clover of earlier years.

FIGURE 7.—During one generation the fertility of some fields has been materially reduced. On the right wheat growing on 70 year old field, on the left line fence.

FERTILITY REMOVED BY CROPPING.

Since unquestionably there has been a decrease in the fertility of most of our soils it is well to study some of the farming systems followed

in the State to learn if possible where the difficulty lies. This is especially desirable since on most farms considerable quantities of manure, clover sod and other organic materials are plowed under. We have worked out in detail the conditions that may exist under several systems of farming.

Conditions on a grain farm. Some farmers follow a system of grain farming. The maximum or greatest, the minimum or lowest and the average losses of certain plant-food constituents are summarized in table 2.

TABLE 2.—Plant food balance on a 100 acre grain farm carrying 2 cows, 5 horses and 14 hogs.

		Nitrogen—pounds.	Phosphoric acid—	Potash—pounds
Plant food in feed and pasture grass		1,630.78	504.04	1,263.42
Loss during digestion and handling of manure	Maximum	938.60	271.48	558.96
	Minimum	739.42	190.51	450.51
	Average	839.01	230.99	504.73
Returned to soil in bedding; stover, etc		684.4	185.84	1,014.90
Total returned to soil	Maximum	1,575.76	499.37	1,827.81
	Minimum	1,376.58	418.40	1,719.36
	Average	1,476.17	458.89	1,773.59
Removed from soil in crops		4,945.5	1,927.53	4,325.13
Annual loss from soil	Maximum	3,568.92	1,509.10	2,605.77
	Minimum	3,369.74	1,428.16	2,497.32
	Average	3,469.33	1,468.64	2,551.54

It is seen that under the conditions given a considerable annual loss of nitrogen, phosphoric acid and potash is sustained on this farm. This is true irrespective of the fact that all stover not fed is plowed under and assuming that there is no loss of plant food from straw used for bedding, a condition which is not true. If all the straw not used on the farm were plowed under instead of being sold, there would still be a net average loss of 2,609.73 pounds of nitrogen, 1,220.24 pounds of phosphoric acid and 1,423.82 pounds of potash.

Conditions on a general farm. In some instances general farming is practiced. The fertility situation as nearly as can be determined is as given in table 3.

TABLE 3.—Plant food balance on a 100 acre general farm, carrying 6 cows, 4 young cattle, 5 horses and 14 hogs.

		Nitrogen—pounds.	Phosphoric acid—pounds.	Potash—pounds.
Plant food in feed and pasture grass		2,645.79	830.71	2,059.79
Loss during digestion and handling of manure	Maximum	1,546.25	459.76	902.89
	Minimum	1,067.40	304.68	679.12
	Average	1,306.82	382.22	791.00
Returned to soil bedding; stover, etc		550.4	145.22	845.83
Total returned to soil	Maximum	2,128.79	671.25	2,226.50
	Minimum	1,649.94	516.17	2,002.73
	Average	1,889.36	593.71	2,114.62
Removed from soil in crops		4,937.45	1,900.17	4,434.16
Annual loss from soil	Maximum	3,287.51	1,384.00	2,431.43
	Minimum	2,808.66	1,228.92	2,207.66
	Average	3,048.09	1,306.46	2,319.54

*A detailed statement of the conditions on the farm is given in the appendix.

The losses of plant-food elements from the 100-acre general farm are somewhat less than from the grain farm of similar size but they are still menacingly large. The keeping of enough livestock to consume a considerable portion of the farm produce has reduced the annual loss of fertility but not so much as is generally believed.

The clover hay has taken its nitrogen from the air rather than from the soil. The amount of nitrogen so removed, however, is equal to the nitrogen contained in the tops or hay, that in the roots being drawn from the soil. It is evident, therefore, that the mere growing of clover does not increase the supply of nitrogen in the soil unless the clover is returned directly or as manure. If the clover is fed to dairy stock a considerable percentage of the nitrogen it contains is retained by the animal. The clover also draws its supply of mineral elements from the soil and hence there is a direct loss of these materials.

In general a larger crop follows the plowing under of a clover sod even when all the hay has been removed. This is due to the fact that the roots, stubble and fallen leaves of clover decomposes rapidly releasing their supply of plant-food elements. This decomposition may force the soil particles to release a portion of their elements in an available form. The result is then available plant-food rather than an increased supply in the soil.

Conditions on a dairy farm. Dairy farming is widely practiced in Michigan. The plant-food condition on a farm carrying sufficient stock to consume practically all the feed crops which can be grown and still maintain a fairly well balanced farming system in addition to purchased concentrates will be studied here.

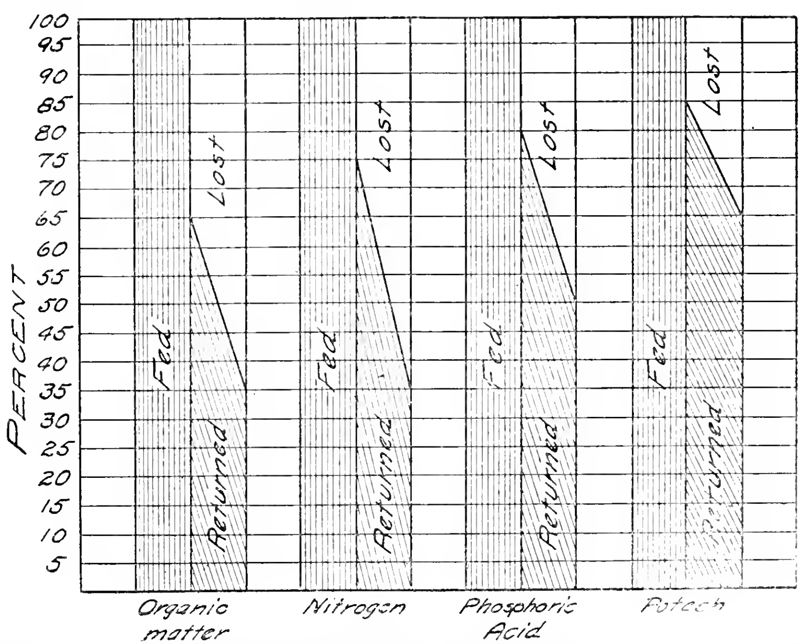


FIGURE 8.—Much organic matter is destroyed and considerable quantities of nitrogen, phosphoric acid and potash are retained by dairy cows.

TABLE 4.—Plant food balance on a 100-acre dairy farm, carrying 20 cows, 10 young cattle, 5 horses and 20 hogs.

		Nitrogen—pounds.	Phosphoric acid—pounds.	Potash—pounds.
Plant food in feed consumed and pasture grass		4,858.4	1,851.72	3,934.19
Loss during digestion and handling of manure	Maximum	2,908.07	1,028.67	1,667.56
	Minimum	1,657.67	514.30	1,129.55
	Average	2,282.87	771.48	1,398.55
Returned to soil in bedding, stover, etc		522.0	145.73	866.80
Total returned to soil	Maximum	3,722.73	1,483.15	3,671.44
	Minimum	2,472.33	968.78	3,133.43
	Average	3,097.53	1,225.97	3,402.44
Removed from soil in crops		5,266.9	1,933.19	5,218.74
Annual loss from soil	Maximum	2,794.57	964.41	2,085.31
	Minimum	1,544.17	450.04	1,547.30
	Average	2,169.37	707.22	1,816.30

The question arises at this point, "Why is it that on livestock farms good yields are still obtained, while where little or no stock is kept the soil depletion is much more evident?" We must remember that most of the plant-food elements in manure are readily available or soon become so. Therefore when manure is applied a quantity of very effective material is added which though it does not equal in amount the material removed from the soil in crops, is very quick to show results. The manure during decay may make available some mineral elements of plant-food. Moreover the soils have been changed more frequently than where grain farming has been followed.

The maximum and minimum and average losses of the plant-food elements are given above. It must be borne in mind that the amount of these nutrients retained by dairy cows varies greatly, those animals giving a large flow of milk naturally retaining more than the less productive individuals. The care with which manure is handled varies greatly. With low producing animals and the best of care the losses may run below the minimum set and on the other hand a combination of higher producing cows and careless handling of manure may result in a greater loss than is indicated by the maximum.

It will be noted in the detailed statements of the operations on these farms, which appear in the appendix that only 10 acres of good clover hay are grown. This represents the condition as it exists on a majority of the farms today but is far from the condition desired and from the farm practices that prevailed in the earlier history of the State. It seems advisable therefore to include a summary of plant-food conditions on a 100-acre general farm growing twenty-five acres of clover. This should permit clover to be grown on every acre once in every four years. The balance on a 100-acre sandy farm using a short rotation including twenty-five acres of clover and five acres of soy beans is also included (tables 5 and 6).

A comparison of the data from the general farms growing small and large acreages of clover respectively shows that the larger acreage of legumes has decreased the loss of nitrogen but has increased the drain on the phosphorus and potassium. This is what would be expected since a large proportion of the hay was sold. However, only three more tons of hay were sold from the general farm than from the dairy farm carrying 20 cows but feeding silage. If the second cutting were turned under

or the straw returned after threshing the loss would be diminished by approximately 750 pounds of nitrogen, 82 pounds of phosphorus and 560 pounds of potassium.

On the sandy farm the losses are not so heavy because the crops produced are not so large.

Table 5.—Plant food balance on a 100-acre general farm, growing 25 acres of clover, and carrying 6 cows, 4 young cattle, 5 horses and 14 hogs.

		Nitrogen—pounds.	Phosphoric acid—pounds.	Potash—pounds.
Plant food in feed consumed and pasture grass		2,641.61	829.22	2,053.24
Loss during digestion and handling of manure	Maximum	1,544.44	468.25	905.33
	Minimum	1,065.18	303.61	676.13
	Average	1,304.81	385.93	790.73
Returned to soil in bedding, stover, etc		268.22	70.71	440.64
Total returned to soil	Maximum	1,844.65	595.29	1,817.75
	Minimum	1,365.39	431.65	1,588.55
	Average	1,605.02	512.97	1,703.15
Removed from soil in crops		3,998.73	1,901.63	4,790.26
Annual loss from soil	Maximum	2,633.34	1,469.98	3,201.71
	Minimum	2,154.08	1,306.34	2,972.51
	Average	2,393.71	1,388.66	3,087.11

Table 6.—Plant food balance on a 100-acre general farm on sandy soil with a short rotation, including 25 acres of clover, and carrying 6 cows, 4 young cattle, 5 horses and 14 hogs.

		Nitrogen—pounds.	Phosphoric acid—pounds.	Potash—pounds.
Plant food in feed consumed and pasture grass		2,701.97	828.08	2,082.34
Loss during digestion and handling of manure	Maximum	1,583.98	458.25	1,015.28
	Minimum	1,097.13	303.56	669.40
	Average	1,340.54	379.53	803.04
Returned to soil in bedding, stover, etc		170.00	78.00	211.00
Total returned to soil	Maximum	1,774.84	602.52	1,623.94
	Minimum	1,287.99	447.80	1,278.06
	Average	1,531.43	526.55	1,490.30
Removed from soil in crops		2,949.27	1,468.88	3,625.90
Annual loss from soil	Maximum	1,661.28	1,021.08	2,347.84
	Minimum	1,174.43	866.36	2,001.96
	Average	1,417.84	942.33	2,135.60

It is impossible to state the actual loss of nitrogen per year on any farm, because there are several variables such as the fixation of nitrogen and the losses due to leaching, erosion, etc. The fact that some soils are growing lighter in color, however, is evidence that a considerable loss of nitrogen is sustained. This is borne out by the results of field experiments quoted later in this publication which show a decided and profitable increase in the yield of wheat on the sandier soils as a result of the use of commercial nitrogen.

A consideration of these farming systems leads to the inevitable conclusion that the fertility of the soil can not be maintained without the supplying of plant-food elements from some exterior source. The source at present available is commercial fertilizers.

THE USE OF FERTILIZERS.

Most farm practices reduce to a greater or less extent soil fertility. In fact it is common knowledge that fertile, virgin soils produce an

abundance of crops without the application of any form of fertilizing materials but later they become less productive and the farmer makes use of farm manure and other materials produced on the farm in order to overcome this condition. Still later materials must be purchased from outside sources if the farm is to continue in its productivity. It is now considered that many new soils also will profitably respond to applications of lime or other materials.

The chief object in view when fertilizers are used is to increase the yield of crops at a maximum profit or in other words to increase the labor income on the farm and it should also be the aim to maintain the fertility of the soil at the some time. There are less acres of land, horse and man hours required to raise a given amount of produce on good land than on land of average fertility or less. This is exemplified by the figures in table 7.

TABLE 7.—Hours of human labor and horse labor and acres of land required to produce the same amount of crops on average land and land properly drained, limed and fertilized.

Crop.	Amount produced.	Average land.			Drained, limed and fertilized land.		
		Acres required.	Man hours.	Horse hours.	Acres required.	Man hours.	Horse hours.
Beans	195 bu	24	810	981	10	350	410
Oats	600 bu	20	252	454	9	113.4	204.3
Wheat	340 bu	22	369.6	778.8	10	168	354
Hay	25 tons	20	98	362	11	53.9	199.1
Total		86	1,559.6	2,578.8	40	685.3	1,167.4

This may be carried farther by showing that the returns for labor are affected by crop yields. Dr. J. I. Falconer of Ohio State University recently reported results of studies made in 1918 of 67 farms in a community in Huron county, Ohio. He reported that these farms lie on the same soil type. They were divided into three groups according to their yields as shown in table 8.

TABLE 8.—Effect of crop yields on labor income.

Crop Yields.	Number of farms.	Value of per day of labor.
Poor	19	$11.92
Fair	20	15.01
Good	18	18.01

The labor income is greatly affected by crop yields or the fertility relationships of the soil. It is good business practice to produce yields of crops considerably above the average of the state.

There are several principles involved in the use of commercial fertilizers that should be considered. Application of fertilizers to soils when the formation of available plant-food from vegetable and mineral matter is slow are frequently desirable. If the spring growth of fall sown grain

is backward because of a severe winter or a late spring the use of light top dressings of nitrates on some soils is a profitable and desirable practice. Where weather conditions are such that very late fall seeding is obligatory or late seeding is practiced on account of the Hessian Fly, the use of readily available fertilizers is urgent in as much as they cause a rapid growth and winter injury is less serious. Moreover where an early marketable crop is desired the use of commercial fertilizers is advisable. In addition the use of readily available fertilizers is sound in regions where the growing period is short since they tend to hasten growth and maturity. Still another point to consider is that fertilizers may increase the root development of plants and consequently their feeding range, thereby assisting them to obtain additional elements of plant-food from the soil. This probably accounts for the benefit derived from small applications. Naturally such practices do not comprise permanent systems of fertility.

The vegetable matter or humus content of soils may be increased by the use of commercial fertilizers. It has been shown that the roots and above ground portions of crops may be increased by this means if proper rotations of crops are followed. There is more material left in soils and larger quantities of residues or manure, straw, etc., to return to the land. If on the other hand the soil is improperly managed or the residues are carelessly handled, burned or not returned to the land, small amounts of available commercial fertilizers will result in more rapid depletion of humus than if they are not used.

Some soils are actually deficient in one or more elements of plant food and fertilizers are added to meet this need. As has been pointed out this is the case with many of Michigan's heavy soils with respect to phosphoric acid, and sandy soils are not only low in phosphoric acid but are also generally deficient in humus and nitrogen. Although potash is usually present in abundance in the mineral soils, we have found that its use on some sandy lands is desirable for the production of the legumes and many growers report also that it is desirable—when prices are normal—for the production of potatoes and root crops. Some muck and peat soils respond to lime, some to phosphoric acid, some to potash, and some to both phosphoric acid and potash.

We have in progress many field tests that are being conducted cooperatively by farmers, county agents and representatives of the Soils Section. It is proposed to continue these at least one round of a rotation and longer if practicable. Although it is recognized that the value of such tests increases with the length of time they are continued, it seems advisable to report the results we have obtained at this time. A summary is given in table 9 followed by a detailed report.

In calculating the returns from the application of the materials applied to the soils the following prices per bushel were used: Wheat, $2.00; corn, $1.25; oats, $0.60; rye, $1.50; soy beans, $5.00. The following in terms of tons: Clover hay, $22.00; straw, $8.00; lime, $4.50; acid phosphate, $32.00; sodium nitrate, $90.00; potash, $176.00, rock phosphate, $20.00; sulphate of ammonia, $100.00. If the price of farm products were only one-half the amounts used and the cost of the fertilizers were the same, naturally the returns derived from their use would be less.

TABLE 9.—A summary of fertility tests.

Farm of	Location.	Treatment.	Soil.	Crops.	Return per acre.
J. Wheeting.........	Imlay City.....	Lime...........	Sand.........	Corn, oats....	$29.95
J. Wheeting.........	Imlay City.....	Lime...........	Sand.........	Wheat.......	7.99
Cass County Farm .	Cassopolis......	Lime...........	Sand.........	Soybeans, rye, wheat.	9.60
Bert Gilbert, Paul Schnelle, Chas. Kinser.	Emmet and Cheboygan counties.	Lime...........	Sand.........	Rye..........	−6.15
Manistee County Farm.	Manistee.......	Lime...........	Sand.........	Rye..........	−4.47
Thos. Moore........	Thompsonville..	Lime...........	Sand.........	Rye..........	.73
Van Buren County Farm.	Hartford.......	Manure........	Sandy loam ..	Oats, clover ..	*10.41
J. Wheeting.........	Imlay City.....	Manure........	Sand.........	Corn, oats....	*30.05
Paul Schnelle........	Clarion.........	Manure........	Sand.........	Rye..........	*18.63
W. C. Kempster.....	Coldwater......	Rock phosphate.	Silt loam.....	Oats, wheat ..	23.88
Van Buren County Farm.	Hartford........	Rock phosphate, with nitrogen and potash.	Sandy loam ..	Oats, clover, 2 crops.	6.64
Van Buren County Farm.	Hartford.......	Rock phosphate, with manure.	Sandy loam ..	Oats, clover, 2 crops.	14.79
Jas. Richards.......	Eau Claire......	Rock phosphate, with marl	Silt loam.....	Oats, wheat ..	−22.35
Cass County Farm .	Cassopolis......	Rock phosphate, with limestone.	Sand.........	Soybeans, wheat, rye.	− .84
B. C. Gilbert, Paul Schnelle, Chas. Kinser.	Emmet and Cheboygan counties.	Rock phosphate.	Sand.........	Rye..........	−12.94
E. D. Fairchilds.....	Constantine....	Rock phosphate.	Sand.........	Corn-rye.....	18.78
B. C. Gilbert, Paul Schnelle, Chas. Kinser.	Emmet and Cheboygan counties.	Acid phosphate .	Sand.........	Rye..........	2.28
		Acid phosphate, sodium nitrate.	Sand.........	Rye..........	13.10
		Acid phosphate, sodium nitrate, potash.	Sand.........	Rye..........	3.49
Cass County Farm .	Cassopolis......	Acid phosphate, lime.	Sand.........	Soybeans, rye, wheat.	.71
		Acid phosphate, sodium nitrate, lime.	Sand.........	Soybeans, rye, wheat.	11.44
		Acid phosphate, sodium nitrate, potash-lime.	Sand.........	Soybeans, rye, wheat.	22.20
Manistee County Farm.	Manistee.......	Acid phosphate .	Sand.........	Rye..........	13.83
		Acid phosphate, sodium nitrate.	Sand.........	Rye..........	12.36
		Acid phosphate, sodium nitrate, potash.	Sand.........	Rye..........	4.50

TABLE 9.—Concluded.

Farm of	Location.	Treatment.	Soil.	Crops.	Return per acre.
W. C. Kempster.....	Coldwater......	Acid phosphate .	Silt loam.....	Oats, wheat ..	26.34
		2-12-2.........	Silt loam.....	Oats, wheat ..	17.83
F. McCartney......	Morrice........	Acid phosphate .	Silt loam.....	Wheat.......	12.35
		Acid phosphate, sodium nitrate.*	Silt loam.....	Wheat.......	21.16
		Acid phosphate, sodium nitrate, potash.	Silt loam.....	Wheat.......	15.06
W. J. Guthrie.......	Mendon........	Acid phosphate .	Silt loam.....	Wheat.......	28.42
		2-12-2.........	Silt loam.....	Wheat.......	28.39
S. Simpson..........	Vicksburg......	Acid phosphate .	Silt loam.....	Wheat.......	16.72
24 trials............	Commercial nitrogen (top dressing)..		Light soils....	Wheat.......	7.98
28 trials............	Commercial nitrogen (top dressing)..		Heavy soils...	Wheat.......	−1.14

*Gross.

RESULTS FROM THE USE OF LIME.

Tests conducted on the farm of John Wheeting in Lapeer county in all cases have shown excellent results from the use of lime. The soil is a rolling sand on sandy silt sub-soil typical of large areas in that section. The land has been farmed a number of years. Lime at the rate of 2 tons per acre was applied in the spring of 1919 for corn. The increase in yield of this crop due to the lime was 19.86 bushels and 920 pounds of stover. The following year oats were seeded on the same areas. The increase in yield of oats due to the lime was 29.33 bushels and 1,280 pounds of straw. After having deducted the cost of lime a return of $29.95 was derived from the first two crops of a four-year rotation.

On the same farm and the same soil type an application of lime on wheat land in the fall of 1919 gave an increase of 6.23 bushels of grain and 832 pounds of straw. The returns above the cost of lime amounted to $7.99 per acre.

Lime is used profitably on the Cass county farm. Experiments to determine the value of lime were started in the spring of 1917 on the Cass county farm. The soil is a sand to sandy loam on a sub-soil of gravelly, silty nature. This land has been farmed for many years and four years previous to 1917 had been idle because it was too poor to produce profitable crops. An application of 6,300 pounds of lime per acre was made on a series of plots with corresponding plots untreated. A four-year rotation of soy beans for seed, rye, wheat and soy beans for green manure, has been followed. The average increase of the limed over the untreated plots is as follows: Soy beans, 1.14 bushels; rye, 1.70 bushels; wheat, 6.5 bushels and 632 pounds of straw; and soy beans, 1,231 pounds of green weight. After deducting the cost of the lime from the first three crops grown in the rotation there remains a balance of $9.60 per acre. On a similar treated series sweet clover was grown as a green manure crop instead of soy beans, the last crop of a four-year rotation. The average of the lime-treated over the unlimed

plots showed an increase of 4,450 pounds of green matter, the quantity of sweet clover produced on the untreated plots being negligible.

On the above soil further work was carried on using different fineness of division of limestone and other forms of lime. A standard application of 4,000 pounds of the carbonate forms, limestone and marl, and an equivalent amount of lime in the hydrated form were used. A rotation of soy beans for seed, rye, wheat and sweet clover for green manure has been followed. Owing to a late spring application of lime and late seeding of soy beans the first year, the crop was very poor and the results are not given. In table 10 are presented the results for the rye and wheat crops.

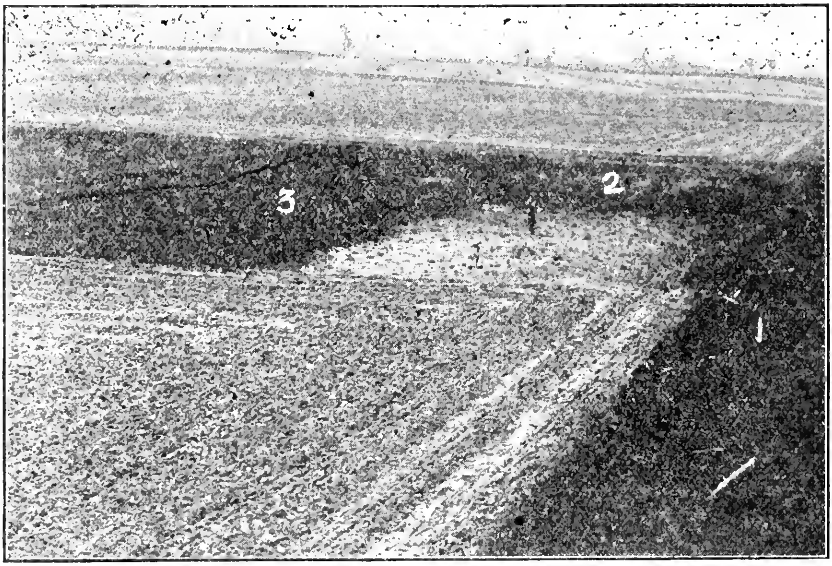


FIGURE 9.—This soil responds to complete fertilizers. No. 1, no treatment; No. 2, lime; No. 3, lime, phosphoric acid and potash. Sweet clover, Cass County Farm.

TABLE 10—Cass County lime experiments.

	Rye, 1918.	Wheat, 1920.	
	Grain—bushels.	Grain—bushels.	Straw—lbs.
Hydrated lime (N 100-P 200)	21.60	16.0	2,112
Marl (N 100-P 200)	18.40	19.2	1,632
80-mesh (N 100-P 200)	21.28	16.0	1,568
40-60-mesh (N 100-P 200)	18.36	15.53	1,568
10-20-mesh (N 100-P 200)	14.40	11.73	1,152
Check (N 100-P 200)	12.42	9.6	1,120
No treatment	12.82	3.46	384

The sweet clover although grown for green manure in the season of 1921 showed little differences in growth where the soil was treated with marl, hydrated lime and 80-mesh limestone. The growth of sweet clover in 1920 was less as the coarseness of the limestone increased.

Lime has been used to less advantage in Emmet and Cheboygan counties. Experiments conducted on sandy soils with light to medium heavy subsoils in Emmet and Cheboygan counties show, as an average of three fields where lime was applied at the rate of 2 tons to the acre, an increase of 1.9 bushels of rye but none in case of the straw. Lime did not affect the growth of the 1920 spring seeding of sweet clover and alfalfa on these projects. It is very doubtful if lime can be used economically on these special types of soil.

Experiments conducted on the Manistee county farm near Manistee and on the farm of Thomas Moore near Thompsonville, indicate that lime may be used with profit in this section. The soils are rather light sands on open sandy subsoils. In each case 2.5 tons of lime were applied in the fall of 1919. On the county farm the lime increased the yield of

FIGURE 10.—Marl brings good results on the farm of S. A. Foster, near Okemos.

rye 4.52 bushels per acre and resulted in an excellent stand of alfalfa that was seeded with the rye. Alfalfa seeded on the untreated land was a failure. On the farm of Mr. Moore the limed plot yielded 7.99 bushels more rye per acre than the unlimed portion of the field. In this case the increased yield of rye the first year of the rotation paid for the cost of the lime and left a profit of 73 cents per acre.

BARNYARD MANURE.

Experiments are being carried on to determine the value of barnyard manure. At the Van Buren county farm near Hartford 10 tons of manure were applied in the spring of 1917. The soil in question is a poor sandy loam. The manure increased the yield of the oat crop 14.6 bushels of grain and 284 pounds of straw. Clover showed a slight gain of 44 pounds per acre. From the two crops the gross returns amount to $10.41 per acre.

Other experiments on the farm of John Wheeting near Imlay City are in progress. The soil is a sand underlaid by a sand silt subsoil

not very retentive of water. The yield from the first two crops of a 4-year rotation is given in table 11.

TABLE 11.—Value of manure on Wheeting Farm.

	Corn.		Oats.	
	Grain—Bu.	Stover—Lbs.	Grain—Bu.	Straw—Lbs.
Manure, 4 tons	42.85	2,860	54.72	2,280
No treatment	35.28	2,800	29.20	960

The gross returns from the manure amounted to $30.05 per acre.

A similar test conducted on the farm of Paul Schnelle near Clarion, Emmet county, gave excellent returns in 1920. Eight tons of manure were applied to a hardwood sand which was later seeded to rye. The increase in yield of rye on the manured plot over the unmanured plot amounted to $18.63 gross per acre the first of a four-year rotation.

TOP DRESSING WHEAT LAND WITH COMMERCIAL NITROGEN.

The value of top dressing wheat with commercial nitrogen has been investigated for two years. The applications were made as early in the spring as the land was in suitable condition for it. Two divisions of soils have been worked on, namely, sands and light sandy loams; and heavy sandy loams and heavier types. All of these lie in the southern half of the lower peninsula. The materials used for top dressing were sodium nitrate and ammonium sulphate. The application consisted of 9.18 pounds of nitrogen per acre or 60 pounds of sodium nitrate and 41.8 pounds of ammonium sulfate. Twenty-four trials have been made on the light types of soil. An average increase of 5.34 bushels over the untreated was obtained where nitrogen was applied. After having deducted the cost of the commercial nitrogen in the form of nitrate of soda the net returns were $7.98 per acre.

Twenty-eight trials have been made on the heavy types of soil. An average of all tests on the heavy soils shows an increase of .78 bushels per acre. After having considered the cost of the nitrogen a loss of $1.14 per acre resulted. The detailed report of these tests is given in the February issue of the 1921 Experiment Station Quarterly.

TESTS WITH ROCK PHOSPHATE—HEAVY SOILS.

Three trials have been made using rock phosphate alone and in combination with other fertilizing materials. Where used alone at the rate of 2,000 pounds per acre on the farm of W. C. Kempster at Coldwater excellent results have been obtained. The soil is a heavy silt loam on a tight subsoil. Two crops, oats and wheat, of a four-year rotation have been harvested and after having deducted the cost of the rock phosphate returns amounting to $23.88 per acre have been derived.

Experiments have been conducted over a three-year period on the Van Buren county farm near Hartford, the soil of which is a heavy sandy loam. In these tests 2,000 pounds of rock phosphate per acre

in combination with nitrogen and potash have been used. From one crop of oats and two crops of clover $6.64 per acre have been obtained, that is above the cost of the phosphate. On the same field rock phosphate has been used at the rate of 1,000 pounds per acre in conjunction with 10 tons of barnyard manure. After having deducted the cost of the phosphate returns of $14.79 per acre have derived from one oat crop and two clover crops.

The use of rock phosphate at the rate of 2,000 pounds in conjunction with marl the first two years of a four-year rotation has shown a net loss of $22.35 per acre on the farm of Jas. Richards near Eau Claire. The soil is a silt loam with a tight subsoil.

LIGHTER TYPES OF SOIL.

Rock phosphate where used on the lighter types of soil has not been as promising in the early stages of the tests as it has when used on heavy land.

Applications of 2,000 pounds of rock phosphate with 3 tons of lime per acre were made on the Cass county farm near Cassopolis. At the end of a four-year rotation of soy beans for seed, rye, wheat and soy beans for green manure, a loss of 84 cents per acre was obtained.

Experiments carried on with sandy soil in Emmet and Cheboygan counties where 2,000 pounds of rock phosphate have been used alone, show an average loss of $12.94 per acre on the first crop of a four-year rotation.

Applications of rock phosphate to a portion of an outwash sand plain, belonging to E. D. Fairchilds, resulted in a loss of $18.78 per acre from two crops, corn and rye, of a four-year rotation.

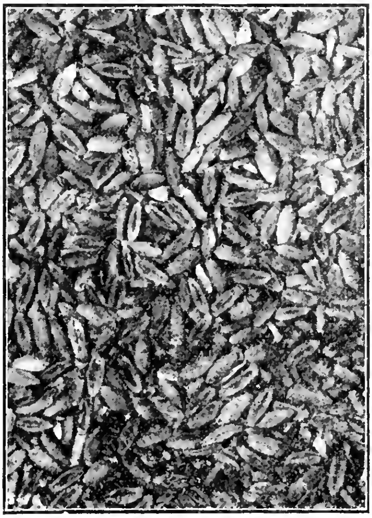
TESTS WITH ACID PHOSPHATE.

The results obtained from experiments with the use of acid phosphate alone and together with combinations of lime, nitrogen and potash vary considerably on heavy and light soils.

LIGHT SOILS, SAND TO LIGHT SANDY LOAMS.

Experiments are being conducted on sandy soils in Emmet and Cheboygan counties. The soil types are hardwood sands with light to medium heavy subsoils. Acid phosphate was applied at the rate of 250 pounds per acre on three separate areas. The average increase of rye for the first year shows 3.73 bushels of grain and 173 pounds of straw over adjacent unphosphated lands. For the first year this gives returns of $2.28 per acre after deducting the cost of the acid phosphate. On the same lands a combination of 250 pounds of acid phosphate and sodium nitrate (100 pounds per acre) was used on rye. The treated plots yielded an increase of 13.82 bushels of grain and 219 pounds of straw, or when the cost of both sodium nitrate and acid phosphate are considered, returns of $13.10 per acre. On the same lands combinations of 250 pounds of acid phosphate, 100 pounds of sodium nitrate and 100 pounds of muriate of potash were used. The combination of the three materials gave an increase of 11.67 bushels of grain and 823 pounds of straw per acre. The returns from the first crop above the cost of materials amounted to $3.49 per acre. Under the conditions of land in this

district it seems from our present knowledge that combinations of acid phosphate and sodium nitrate will give the most profitable returns.



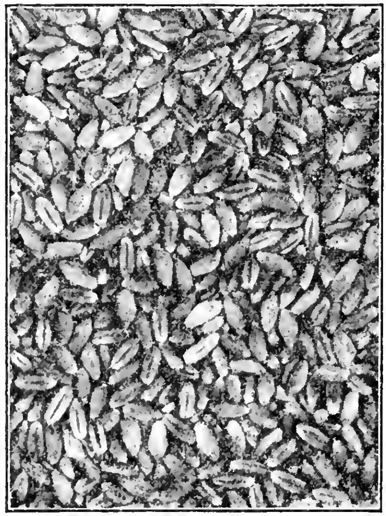


FIGURE 11.—Acid phosphate where needed improves the quality of grain. On the right, grain grown on phosphated land; on the left, none. W. J. Guthrie Farm, Mendon.

The results obtained in Cass county are striking. Experiments were inaugurated in 1917 on the Cass county field spoken of previously. Acid phosphate was applied twice during a four-year rotation on land limed at the rate of 3.15 tons per acre. A four-year rotation of soybeans for seed, rye, wheat and soybeans for green manure was followed with the following increase in yields: Soybeans, .02 bushels; rye, 2.10 bushels; wheat, 1.93 bushels and 450 pounds of green weight in soybeans. The profit above the cost of material amounted to 71 cents per acre. Where acid phosphate was combined with sodium nitrate (100 pounds per acre each year) on the same soil and the same rotation it gave the following increases in yield over limed check plots: soybeans, .77 bushel; rye, 4.09 bushels; wheat, 10.67 bushels, green weight of soybeans 680 pounds or returns of $11.44 per acre after deducting costs of materials. When acid phosphate was used in connection with sodium nitrate (100 pounds per acre per rotation) and 100 pounds of muriate of potash per four-year rotation the increase over the lime-treated check amounted to the following: Soybeans, 1.07 bushels; rye, 10.42 bushels; wheat, 14.91 bushels and green weight of soybeans 680 pounds or a profit after deducting the cost of material of $22.20 per acre.

Similar tests are being conducted on two poor sandy soils in Manistee county. Acid phosphate when used alone at the rate of 250 pounds per acre has increased the average yield of rye on the two fields, 9.22 bushels and 620 pounds of straw. Although this is only the first crop of a four-year rotation after deducting the cost of the materials a profit of $13.83 per acre remains. On the same soil acid phosphate in combination with sodium nitrate (100 pounds per acre per year) gave an average increase of rye over an untreated plot of 12.28 bushels of grain and 612 pounds

of straw or a profit of $12.36 per acre above the cost of the fertilizing materials. When acid phosphate was used in combination with sodium nitrate (100 lbs. per acre) and potash as the muriate, at the rate of 100 pounds per acre per rotation an average increase of 11.97 bushels of grain and 964 pounds of straw resulted. After deducting the cost of materials a return of $4.50 was obtained.

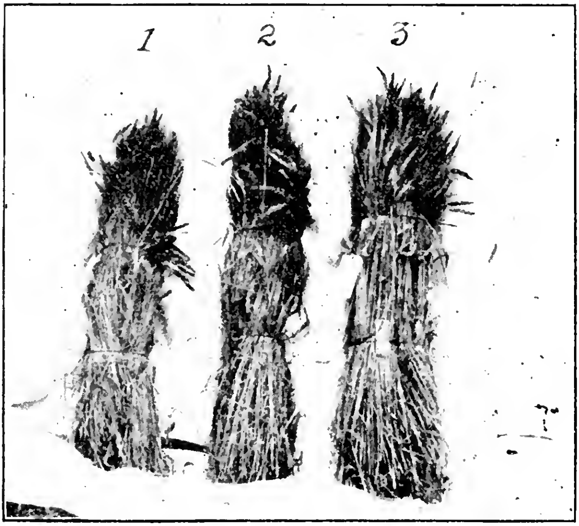


FIGURE 12—Complete fertilizers are profitable on the farm of M. A. Sowerby, Irving. No. 1, acid phosphate; No. 2, acid phosphate and nitrate of soda; No. 3, the same as No. 2, plus potash.

HEAVY SANDY LOAMS, SILT LOAMS.

Acid phosphate when used alone on heavy types of soil with rather impervious subsoils has given good returns.

Fertilizer tests are being conducted on the farm of W. C. Kempster near Coldwater. This soil is a heavy silt loam on a rather heavy clay subsoil. Acid phosphate was applied at the rate of 200 pounds per acre. The increase in yield of oats and wheat, the first two crops of the rotation is as follows: Oats, 5.15 bushels of grain, straw 788 pounds, and wheat 10.15 bushels of grain and 750 pounds of straw. After deducting the cost of the material a profit of $26.34 per acre remains. On the same soil an application of 266 pounds per acre of a 2-12-2 commercial fertilizer, which adds the same amount of phosphoric acid per acre as the acid phosphate, the increase in grain due to this fertilizer amounted to 12 bushels of oats, 656 pounds of straw, 4.93 bushels of wheat and 630 pounds of straw. The profits above the cost of the fertlizer amounted to $17.83 per acre.

Similar work is being carried on on the farm of Mr. McCartney near Morrice. The soil is composed of a typical silt loam on a clay subsoil which has been farmed for a long period of years. An application of acid phosphate at the rate of 250 pounds per acre resulted in an increase of 8.68 bushels of wheat per acre or a return of $12.35 per acre above the cost of the fertilizer. On this same field 250 pounds of acid phosphate and sodium nitrate (100 pounds per acre) gave an increase of

FIGURE 13.—250 pounds of a 2–12–2 increased the yield of wheat 16.7 bushels per acre. W. J. Guthrie's Farm, Mendon.

14.83 bushels of wheat per acre or a return of $21.16 when the cost of the materials is deducted. On an adjacent plot acid phosphate, sodium nitrate and muriate of potash (100 pounds per acre) were applied. They increased the yield of wheat 16.18 bushels over an adjacent untreated part of the field. The profits amounted to $15.06.

Acid phosphate was applied at the rate of 250 pounds per acre to a silt loam on a tight subsoil belonging to W. J. Guthrie near Mendon. The increase in wheat due to the fertilizer amounted to 16.21 bushels per acre. The value of the increase amounted to $28.42 after the cost of the phosphate was deducted. A 2-12-2 fertilizer was applied to an adjacent plot at the rate of 250 pounds per acre and resulted in an increase of 16.73 bushels of wheat per acre which gave a return of $28.39 above the cost of the material.

An application of 200 pounds per acre of acid phosphate on the farm of S. Simpson near Vicksburg, whose soil is a silt loam on a tight subsoil, gave an increase in yield of 9.96 bushels of wheat, the profit amounting to $16.72 per acre.

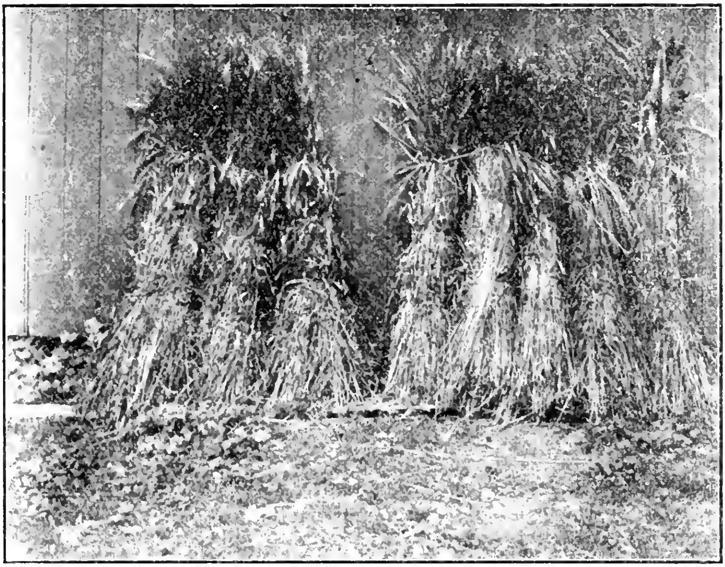


FIGURE 14.—Simpson Farm. Acid phosphate and no treatment.

FERTILITY REMOVAL AND FARM PROFITS.

It is highly desirable for a farmer to know what it costs him to produce his various crops. This cost is complicated by many conditions one of which is the removal of plant-food elements from the soil. The question that has been asked us is—"What constitutes a reasonable charge for this loss of fertility?" In replying to this question it must be borne in mind that few if any soils contain the various plant food elements in the same proportion in which they occur in crops. That is to say a soil may contain a sufficient amount of one element to produce several hundred or possibly a thousand maximum crops. An addition of this element may not markedly increase the yield and its use except in small amounts to increase the readily available supply may not be good agricultural practice. It does not appear to be logical to take into account the removal of elements which are present in abundance, and which when applied do not increase the yield. Later if the supply of such becomes so depleted that their application to the soil increases the yield it will then be proper to add their cost to the other items. On the other hand there may be so little of a certain element or elements that an application of it or them to the soil in the form of commercial fertilizers materially increases the yield. It is good business practice to supply the deficient element or elements if it can be done profitably.

Potash is present in relative abundance in most of our soils. Many muck and peat deposits are so deficient in it that they soon require its addition in some form in order to produce satisfactory yields as well

as suitable quality of crops. If it is necessary to apply this material to the mineral soils to increase the available supply the amount required should be considered in estimating the returns from the land.

Chemical analyses and field experiments have shown that most Michigan soils are deficient in and respond to applications of phosphoric acid. The cost of such applications therefore may reasonably be included in calculating the returns. This may be simplified by charging the cost of a 400-pound application of 16% acid phosphate per acre every four years. This amount is sufficient to produce approximately 25 bushels of wheat, 40 bushels of corn, 50 bushels of oats and 2 tons of clover not including the straw and stover. The majority of our soils also need approximately two tons of ground limestone every six years and the cost of this should be spread over the various crops as shown later.

Nitrogen is present in such quantities that the supply must be maintained and in many soils increased in order to give the most economical yields. The farmer is warranted therefore in adding the cost of replacing this nitrogen by means of legumes to the price of his products. If conditions are such however that nitrogen must be applied in the commercial form the cost of adding this to the soil should be included.

This raises the question of the cost of production of a pound of nitrogen on the farm. The cost of production of a pound of nitrogen by means of leguminous crops in a rotation is difficult to determine. It should be conceded that much of the benefits derived from the use of lime is due to its effect on the legumes such as clovers and alfalfa. It seems fair to charge two-thirds the cost of the lime to these crops and also the phosphate that should be added to the soil for their benefit. If two tons of lime are applied per acre and endure six years and a four-year rotation is followed and two seedings of clover, vetch or soy beans are obtained and one hundred pounds of acid phosphate are added to each seeding the cost of nitrogen runs from five to eight cents a pound. If no lime is added to the land naturally the cost is less or from two to four cents. Alfalfa is the cheapest source of nitrogen. On the same basis as in the first case above, nitrogen may be produced for less than one-half what it costs when obtained by means of other legumes. If the crop stands four years instead of six the cost is slightly higher.

APPENDIX.

The balance of plant-food elements on farms differently managed has been worked out in detail but owing to the size and complexity of the tables it seemed advisable to submit them as an appendix rather than earlier in the publication.

In making these calculations information gained by Dr. H. G. Armsby in his digestion experiments was made use of. For the composition of the various farm crops the tables published by Dr. L. Van Slyke and Dr. C. G. Hopkins were utilized. Information concerning the number of stock found on the types of farms considered and the amounts of feed of various kinds consumed was obtained from members of the Animal Husbandry and Dairy Sections. We desire to express our appreciation of this co-operation.

47

100 ACRE GRAIN FARM, CARRYING

Crops produced.	Plant-food elements in produce.			Consumed by stock.			
	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
Hay, 10 A.-20 T......	*800.0	201.5	720.0	12.5 T ..	500	125.95	450.0
Corn, 15 acres:							
Grain, 600 bu......	556.8	219.87	132.0	45 bu....	41.76	16.49	9.9
Stover, 18.1 T.....	362.0	110.53	505.4	3 T......	60.0	18.31	83.77
Oats, 20 acres:							
Grain, 1,200 bu......	768.0	318.81	230.4	613 bu...	392.32	162.81	117.70
Straw, 30 T........	384.0	120.93	748.8	Fed., 5 T.	64.0	20.16	124.8
				Bed.5.5 T.	....	....	....
Total consumed by stock..............	....	....	....	....	1,058.08	343.72	786.17
Wheat, 25 acres:							
Grain, 625 bu......	750.0	320.00	150.0	....	....	....	....
Straw, 31 T........	310.0	94.24	371.0	....	....	....	....
Beans, 15 acres:							
Grain, 300 bu......	720.0	219.87	234.28	....	....	....	....
Straw, 12 T........	312.0	71.46	456.00	....	....	....	....
Potatoes, 5 acres: 1,000 bu...........	210.0	90.0	300.0	....	....	....	....
Pasture, 10 acres.....	572.7	160.32	477.25	....	572.7	160.32	477.25
Total removed from soil................	4,945.5	1,927.53	4,325.13	....	....	....	....

*Taken from the air.

2 COWS, 14 HOGS, 5 HORSES.

Sold from farm.				Returned to soil.			
Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
7.5 T...........	300.00	75.55	270.0	....	....	....	....
555 bu.........	515.04	203.38	122.1	.... 15.1 T...	.... 302.0	.... 92.21	.... 421.62
587 bu......... 19.5 T.........	375.68 249.6	156.00 78.61	112.70 486.72	....	.... 70.4	.... 22.17	.... 137.28
....	....	....	....	....	....	....	....
625 bu......... 31 T...........	750.0 310.0	320.0 94.24	150.0 371.0	....	....	....	....
300 bu.........	720.0	219.87	234.28	.... 12 T.....	 312	.... 71.46	.... 456.00
1,000...........	210.0	90.0	300.0	....	....	....	....
....	....	....	....	....	....	....	....
Total...........	3,430.32	1,237.65	2,046.80	Total....	684.4	185.84	1,014.90

GENERAL FARM, CARRYING 6 COWS,

Crops produced.	Plant-food elements in produce.			Consumed by stock.			
	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
Hay, 10 acres-20 T....	*800.0	201.5	720.0	17 T.....	680.0	171.28	612.0
Corn, 15 acres: Grain, 600 bu...... Stover, 18.1 T.....	 556.8 362.0	 219.87 110.53	 132.0 505.4	 287 bu... 11.3 T...	 266.34 226.0	 105.17 69.0	 63.14 315.49
Oats, 15 acres: Grain, 900 bu...... Straw, 22.5 T......	 576.0 288.0	 239.11 90.70	 172.8 561.6	 800 bu... Fed., 8 T. Bed., 8 T	 512.0 102.4	 212.54 32.24	 153.6 199.68 ....
Total consumed by stock............	....	....	....	....	1,786.74	590.23	1,343.91
Barley, 10 acres: Grain, 340 bu...... Straw, 11 T........	 285.6 132.0	 124.6 43.51	 81.6 242.0				 ....
Wheat, 15 acres: Grain, 375 bu...... Straw 18.6.	 450.0 186.0	 192.00 56.54	 90.0 222.6				 ....
Beans, 15 acres: Grain, 300 bu...... Straw, 12 T........	 720.0 312.0	 218.87 71.46	 234.28 456.00				 ....
Potatoes, 5 acres: 1,000 bu...........	 210.0	 90.0	 300.0				 ....
Pasture, 15 acres.....	859.05	240.48	715.88	....	859.05	240.48	715.88
Total removed from soil...............	4,937.45	1,900.17	4,434.16	....	....	....	....

* Taken from the air.

14 HOGS, 4 CATTLE, 5 HORSES.

Sold from farm.				Returned to soil.			
Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
3 T.	120.0	30.22	108.0	...	...	...	...
313 bu.	290.46	114.70	68.86	...	...	...	...
...	...	...	...	6.8 T.	136.0	41.52	190.15
100 bu.	64.0	26.56	19.2	...	...	...	...
6.5 T.	83.2	26.20	162.24	...	...	...	...
...	...	...	...	8 T.	102.4	32.24	199.68
...	...	...	...	...	...	...	...
340 bu.	285.6	121.6	81.6	...	...	...	...
11 T.	132.0	43.51	242.0	...	...	...	...
375 bu.	450.0	192.0	90.0	...	...	...	...
18.6 T.	186.0	56.54	222.6	...	...	...	...
300 bu.	720.0	219.87	231.28	...	...	...	...
...	...	...	...	12 T.	312.0	71.46	456.0
1,000 bu.	210.0	90.0	300.0	...	...	...	...
...	...	...	...	...	...	...	...
Total.	2,541.26	924.20	1,528.78	Total.	550.4	145.22	845.83

DAIRY FARM, 20 COWS, 5

Crops produced.	Plant-food elements in produce.			Consumed by stock.			
	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
Hay, 10 A-20 T......	*800.0	201.5	720.0	20 T.....	800.0	201.5	720.0
Corn, 10 acres:							
Grain, 400 bu......	371.2	146.56	88.0	250 bu...	232.0	91.6	55.0
Stover, 12 T.......	240.0	73.28	336.0	7.5 T....	150.0	45.8	210.0
Corn, 10 acres:							
Silage, 100-T.......	680.0	229.00	880.0	100 T....	680.0	229.0	880.0
Oats, 20 acres:							
Grain, 1,200 bu....	768.0	318.77	230.4	800 bu...	512.0	212.51	153.6
Straw, 30 T........	384.0	120.91	748.8	Fed.,6.5 T.	83.2	26.1	162.24
				Bed.17.5 T	....	....	....
Barley, 10 acres:							
Grain, 340 bu......	285.6	124.57	81.6	340 bu...	285.6	124.57	81.6
Straw, 11 T........	132.0	43.51	242.0	....	....	....	....
Beans, 10 acres:							
Grain, 200 bu......	480.0	146.56	156.19	....	....	....	....
Straw, 8 T.........	208.0	47.63	304.00	....	....	....	....
Purchased bran: 7.5 T..............	....	....	....	7.5 T....	397.5	439.74	240.00
Total consumed by stock.............	....	....	....	....	3,140.3	1,370.82	2,502.44
Pasture, 30 A........	1,718.1	480.9	1,431.75	....	....	....	....
Total removed from soil................	5,266.9	1,933.19	5,218.74	....	....	....	....

*Taken from the air.

HORSES, 10 CATTLE, 20 HOGS.

Sold from farm.				Returned to soil.			
Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
....	....	....	....	....	....	....	....
150 bu........	139.2	54.96	33.0	....	....	....	....
....	....	....	....	4.5 T....	90.0	27.48	126.0
....	....	....	....	....	....	....	....
400 bu........	256.0	106.25	76.8	....	....	....	....
6 T........	76.8	24.18	149.76	....	....	....	....
....	....	....	....	17.5 T...	224.0	70.62	436.8
....	....	....	....	....	....	....	....
11 T........	132.0	43.58	242.0	....	....	....	....
200 bu........	480.0	146.56	156.19	....	....	....	....
....	....	....	....	8 T.....	208.0	47.63	304.0
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
Total........	1,084.0	375.53	657.75	Total..	522.0	145.73	866.8

PLANT FOOD BALANCE ON A 100-ACRE GENERAL FARM GROWING 25 ACRES

Crops produced.	Plant-food elements in produce.			Consumed by stock.			
	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
Clover hay, 25 A-50 T.	*2,000.0	503.75	1,800.00	17 T.....	680.00	171.28	612.00
Corn, 10 acres:							
Grain, 400 bu......	371.2	146.58	88.00	287 bu...	266.34	105.17	63.14
Stover, 12.33 T....	242.0	73.68	336.94	11.3 T...	221.82	67.51	308.94
Oats, 15 acres:				800 bu...	512.00	212.54	153.60
Grain, 900 bu......	576.0	239.11	172.80	Fed., 8 T.	102.40	32.24	199.68
Straw, 22.5 T......	288.0	90.70	561.60	Bed, 8 T.	....	....	....
Wheat, 17 acres:							
Grain, 425 bu......	510.0	217.60	102.00	....	....	....	....
Straw, 21 T........	210.8	64.05	252.28	....	....	....	....
Potatoes, 3 acres:							
600 bu.............	126.0	57.00	180.00	....	....	....	....
Beans, 7 acres, 140 bu.:	336.0	102.60	109.34	....	....	....	....
Straw, 5.6 T.......	145.6	32.32	212.80	....	....	....	....
Barley, 8 acres:							
Grain, 272 bu......	228.48	99.68	65.02	....	....	....	....
Straw, 8.8 T.......	105.6	34.08	193.60	....	....	....	....
Pasture, 15 acres.....	859.05	240.48	715.88	....	859.05	240.48	715.88
Total................	3,998.73	1,901.63	4,790.26	....	2,641.61	829.22	2,053.24

OF CLOVER AND CARRYING 6 COWS, 4 CATTLE, 14 HOGS AND 5 HORSES.

Sold from farm.				Returned to farm.			
Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
33 T............	1,320.00	332.47	1,188.00	....	....	....	....
113 bu...........	104.86	41.41	24.86	....	....	....	....
....	....	....	....	1.03......	20.22	6.15	28.16
100 bu...........	64.00	26.56	19.20	....	....	....	....
6.5 T............	83.20	26.19	162.24	....	....	....	....
....	....	....	....	8 T......	102.40	32.24	199.68
425 bu..........	510.00	217.60	102.00	....	....	....	....
21 T............	210.80	64.05	252.28	....	....	....	....
600 bu...........	126.00	57.00	180.00	....	....	....	....
140 bu...........	336.00	102.60	109.34	....	....	....	....
....	....	....	....	5.6 T....	145.60	32.32	212.80
272 bu..........	228.48	99.68	65.02	....	....	....	....
8.8 T............	105.60	34.08	193.60	....	....	....	....
....	....	....	....	....	....	....	....
....	3,088.94	1,001.61	2,296.54	....	268.22	70.71	440.64

PLANT FOOD BALANCE ON A 100-ACRE SANDY FARM WITH A SHORT ROTATION, AND 5

Crops produced.	Plant-food elements in produce.			Consumed by stock.			
	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
Clover hay, 25 A-37.5 T	*1,500.00	377.81	1,350.00	20.5 T ..	820.00	206.53	738.00
Soybeans, 5 acres:							
Grain, 60 bu.......	190.80	64.80	72.00	....	....	....	....
Tops, 5 T.........	90.00	30.00	75.00	....	....	....	....
Corn, 13 acres:							
Grain, 390 bu......	361.92	142.91	85.80	390 bu...	361.92	142.91	85.80
Stover, 11.7 T.....	234.00	71.44	326.66	11.7 T...	234.00	71.44	326.66
Barley, 9 acres:							
Grain, 225 bu......	189.00	82.46	54.00	225 bu...	189.00	82.46	54.00
Straw, 7.5 T.......	90.00	29.66	165.00	....	....	....	....
Beans, 5 acres:							
Grain, 75 bu.......	180.00	54.96	58.56	....	....	....	....
Straw, 3 tons.......	78.00	17.86	114.00	3 T......	78.00	17.86	114.00
Rye, 20 acres:							
Grain, 400 bu......	382.00	196.00	134.00	....	....	....	....
Straw, 20 T........	200.00	120.00	340.00	....	....	....	....
				Bed., 8 T.	....	....	....
Potatoes, 3 acres:							
450 bu............	94.50	40.50	135.00	....	....	....	....
Pasture, 20 acres.....	859.05	240.48	715.88	....	859.05	240.48	715.88
Bought 250 bu. oats...	....	....	....	250 bu...	160.00	66.40	48.00
Total.............	2,949.27	1,468.88	3,625.90	....	2,701.97	828.08	2,082.34

*Taken from the air.

INCLUDING 25 ACRES OF CLOVER AND CARRYING 6 COWS, 4 CATTLE, 14 HOGS HORSES.

Sold from farm.				Returned to soil.			
Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.	Produce.	Nitrogen, pounds.	Phosphoric acid, pounds.	Potash, pounds.
17 T............	.. 680.00	171.27	612.00	....	....	....	....
60 bu...........	190.80	64.80	72.00	....	....	....	....
....	....	....	....	5 T......	90.00	30.00	75.00
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
7.5 T..........	90.00	29.66	165.00	....	....	....	....
75 bu...........	180.00	54.96	58.56	....	....	....	....
....	....	....	....	....	....	....	....
400 bu..........	382.00	196.00	134.00	....	....	....	....
12 T............	120.00	72.00	204.00	....	....	....	....
....	....	....	....	8 T......	80.00	48.00	136.00
450 bu..........	94.50	40.58	135.00	....	....	....	....
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
....	1,737.30	629.19	1,380.56	....	170.00	78.00	211.00

IMPORTANT NOTICE

During the last regular session of the legislature the bill (Act 13, P. A. 1921) creating the Department of Agriculture was passed. By the provisions of this bill the inspection of commercial feeding stuffs, will after July 1st, 1921, be conducted under the direction of the Department of Agriculture. All communications in regard to the licensing or inspection and analysis of commercial feeding stuffs should after the above mentioned date, be directed to the Commissioner of Agriculture, Lansing, Michigan.

COMMERCIAL FEEDING STUFFS

Regular Bulletin No. 292

BY ANDREW J. PATTEN, O. B. WINTER, M. L. GRETTENBERGER, P. O'MEARA
CHEMICAL SECTION

This bulletin contains the results of the inspection of commercial feeding stuffs during the period from September 1920 to June 1921. During this time 529 samples were collected and analyzed. This is, by far, the smallest number of samples that have ever been collected during a similar period, since the inspection has been carried on by the Chemical Section of the Michigan Agricultural Experiment Station under the supervision of the State Board of Agriculture. The unusual economic conditions that prevailed during the past nine months caused a tremendous falling off in the commercial feed business. The movement of mixed feeds, during the winter months especially, was extremely light. On the other hand, the sharp decline in the price of cottonseed meal, that occurred in the early winter stimulated its demand and the movement of this concentrate was greater than ever before. Furthermore, the quality of the cottonseed meal shipped into the State during the past winter was far superior to that of former years, the great bulk of the shipments being 43% protein meal.

The inspection of commercial feeding stuffs has been conducted by the chemical section of the Experiment Station since January 1916. The effect of this inpsection upon the quality of the feeds sold in the State is clearly demonstrated in the following table, which shows the percentage of samples not equal to guarantee for both years.

Year ending July 1	1916	1921
Deficient in protein	15.0%	5.8%
Deficient in crude fat	11.5	2.8
Excess of crude fiber	9.9	2.4

More striking still is the comparison of the inspection results covering cottonseed meal for the same years as shown in the following table:

Year ending July 1	1916	1921
Deficient in protein	51.0%	4.7%
Deficient in crude fat	6.2	1.0
Excess of crude fiber	39.6	2.3

COOPERATION WITH U. S. DEPT. OF AGRICULTURE

Through a cooperative arrangement with U. S. Department of Agriculture, all interstate shipments of commercial feeding stuffs found to be below guarantee or that any other respect have been shipped in violation of the provisions of the Federal Food and Drug act are referred to the U. S. Food and Drug Inspection Station, Central District, Chicago, Ill. During the past year sixteen samples have been disposed of in this way. In fifteen of the cases citations have been issued and the other case is still under investigation.

DEFINITIONS OF FEEDING STUFFS

It is important that farmers become familiar with the names and descriptions of commercial feeding stuffs, as these are used by feed manufacturers in listing the ingredients of mixed feeds. The definitions as amended and adopted by the Association of Feed Control Officials of the United States at its last meeting are as follows:

Meal is the clean, sound, ground product of the entire grain, cereal or seed which it purports to represent.

Chop is a ground or chopped feed composed of one or more different cereals or by-products thereof. If it bears a name descriptive of the kind of cereals, it must be made exclusively of the entire grains of those cereals.

Alfalfa meal is the entire alfalfa hay ground, and does not contain an admixture of ground alfalfa straw or other foreign materials.

ANIMAL PRODUCTS.

Blood Meal is ground dried blood.

Cracklings are the residue after partially extracting the fats and oils from the animal tissues. If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

Digester Tankage is the residue from animal tissues, exclusive of hoof and horn, specially prepared for feeding purposes by tanking under live steam, drying under high heat, and suitable grinding. If it contains more than 10 per cent of phosphoric acid (P_2O_5) it must be designated *Digester Meat and Bone Tankage.*

Meat Scrap and Meat Meal are the ground residues from animal tissues exclusive of hoof and horn. If they contain more than 10 per cent of phosphoric acid (P_2O_5) they must be designated *Meat and Bone Scrap and Meat and Bone Meal.* If they bear a name descriptive of their kind, composition or origin, they must correspond thereto.

BARLEY PRODUCTS.

Barley Hulls are the outer chaffy coverings of the barley grain.

Barley Feed is the entire by-product resulting from the manufacture of pearl barley from clean barley.

Barley Mixed Feed is the entire offal from the milling of barley flour from clean barley and is composed of barley hulls and barley middlings.

BREWERS' AND DISTILLERS' PRODUCTS.

Brewers' Dried Grains are the properly dried residue from cereals obtained in the manufacture of beer.

Distillers' Dried Grains are the dried residue from cereals obtained in the manufacture of alcohol and distilled liquors. The product shall bear the designation indicating the cereal predominating.

Distillers' Corn Solubles, a by-product from the manufacture of alcohol from corn, is a mash liquor concentrated after the removal of the alcohol and wet grains.

Distillers' Corn and Rye Solubles, a by-product from the manufacture of alcohol from corn and rye, is a mash liquor concentrated after the removal of the alcohol and wet grains.

Distillers' Rye Solubles, a by-product from the manufacture of alcohol from rye, is a mash liquor concentrated after the removal of the alcohol and wet grains.

Malt Sprouts are the sprouts of the barley grain. If the sprouts are derived from any other malted cereal, the source must be designated.

BUCKWHEAT PRODUCTS.

Buckwheat Shorts or Buckwheat Middlings are that portion of the buckwheat grain immediately inside of the hull after separation from the flour.

CORN PRODUCTS.

Corn Bran is the outer coating of the corn kernal.

Corn Feed Meal is the by-product obtained in the manufacture of cracked corn, with or without aspiration products added to the siftings, and is also the by-product obtained in the manufacture of table meal from the whole grain by the non-degerminating process.

Corn Germ Meal is a product in the manufacture of starch, glucose and other corn products, and is the germ layer from which part of the corn oil has been extracted.

Grits are the hard, flinty portions of Indian corn, without hulls and germs.

Corn Gluten Meal is that part of commercial shelled corn that remains after the separation of the larger part of the starch, the germ and the bran, by the processes employed in the manufacture of cornstarch and glucose. It may or may not contain corn solubles.

Corn Gluten Feed is that portion of commercial shelled corn that remains after the separation of the larger part of the starch and the germs by the processes employed in the manufacture of cornstarch and glucose. It may or may not contain corn solubles.

Hominy Feed, Hominy Meal or Hominy Chop is the kiln dried mixture of the mill run bran coating, the mill run germ, with or without a partial extraction of the oil and a part of the starchy portion of the white corn kernel obtained in the manufacture of hominy, hominy grits and corn meal by the degerminating process.

Yellow Hominy Feed, Yellow Hominy Meal or Yellow Hominy Chop is a kiln dried mixture of the mill run bran coating, the mill run germ, with or without a partial extraction of the oil and a part of the starchy portion of the yellow corn kernel obtained in the manufature of yellow hominy grits and yellow corn meal by the degerminating process.

OIL CAKE.

Oil Cake is the residual cake obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term ''oil cake'' shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product, the name of the seed from which it is obtained shall be prefixed to ''oil cake.''

Ground Oil Cake is the product obtained by grinding oil cake. When used alone, the term ''ground oil cake'' shall be understood to designate the product obtained from partially extracted, screened and cleaned flaxseed. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to ''ground oil cake.''

COTTONSEED PRODUCTS.

Cottonseed Meal is a product of the cottonseed only, composed principally of the kernel with such portion of the hull as is necessary in the manufacture of oil; provided that nothing shall be recognized as cottonseed meal that does not conform to the foregoing definition and that does not contain at least 36 per cent of protein.

Choice Cottonseed Meal must be finely ground, not necessarily bolted, perfectly sound and sweet in odor, yellow, free from excess of lint, and must contain at least 41 per cent of protein.

Prime Cottonseed Meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, yellow, not brown or reddish, free from excess of lint, and must contain at least 38.6 per cent of protein.

Good Cottonseed Meal must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, and must contain at least 36 per cent of protein.

Cottonseed Feed is a mixture of cottonseed meal and cottonseed hulls, containing less than 36 per cent of protein.

Cold Pressed Cottonseed is the product resulting from subjecting the whole undecorticated cottonseed to the cold pressure process for the extraction of oil, and includes the entire cottonseed less the oil extracted.

Ground Cold Pressed Cottonseed is the ground product resulting from subjecting the whole undecorticated cottonseed to the cold pressure process for the extraction of oil, and includes the entire ground cottonseed less the oil extracted.

LINSEED AND FLAX PRODUCTS.

Linseed Meal is the ground product obtained after extraction of part of the oil from ground flaxseed screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes, provided that the

final product shall not contain over six per cent of weed seeds and other foreign materials and provided further that no portion of the stated six per cent of weed seeds and other foreign materials shall be deliberately added.

Oil Meal is the ground product obtained after the extraction of part of the oil by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents from seeds which have been screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term ''Oil Meal'' shall be understood to designate linseed meal as defined. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to the words ''oil meal.''

Old Process Oil Meal is the ground product obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term ''Old Process Oil Meal'' shall be understood to designate linseed meal as defined, made by the old process. When used to cover any other product the name of the seed from which it is obtained shall prefixed to ''old process oil meal.''

New Process Oil Meal is the ground product obtained after extraction of part of the oil by crushing, heating and the use of solvents from seeds screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes. When used alone the term ''New Process Oil Meal'' shall be understood to designate linseed meal as defined, made by the new process. When used to cover any other product the name of the seed from which it is obtained shall be prefixed to ''new process oil meal.''

Flax Plant By-Product is that portion of the flax plant remaining after the separation of the seed, the bast fiber and a portion of the shives, and consists of flax shives, flax pods, broken and immature flax seeds, and the cortical tissues of the stem.

Ground Flaxseed or Flaxseed Meal is the product obtained by grinding flaxseed which has been screened and cleaned of weed seeds and other foreign materials by the most improved commercial processes, provided that the final product shall not contain over four per cent of weed seeds and other foreign materials, and provided further that no portion of the stated four per cent of weed seeds and other foreign materials shall be deliberately added.

Unscreened Flaxseed Oil Feed is the ground product obtained after extraction of part of the oil from unscreened flaxseed by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents. When sold without grinding the unground product shall be designated as ''unscreened flaxseed oil feed cake.''

Ingredients of Unscreened Flaxseed Oil Feed—Ground cake from partially extracted flaxseed and foreign seeds (wheat, wild buckwheat, pigeon grass, wild mustard, etc.)

Screenings Oil Feed is the ground product obtained after extraction of part of the oil by crushing, cooking and hydraulic pressure, or by crushing, heating and the use of solvents from the smaller imperfect grains, weed seeds and other foreign materials, having feeding value, separated in cleaning the grain. The name of the grain from which the screenings are separated shall be prefixed to ''screenings oil feed.''

OAT PRODUCTS.

Oat Groats are the kernels of the oat berry.

Oat Hulls are the outer chaffy coverings of the oat grain.

Oat Middlings are the floury portions of the oat groat obtained in the milling of rolled oats.

Oat Shorts are the covering of the oat grain lying immediately inside the hull, being a fuzzy material carrying with it considerable portions of the fine floury part of the groat obtained in the milling of rolled oats.

Clipped Oat By-Product is the resultant by-product obtained in the manufacture of clipped oats. It may contain light chaffy material broken from the ends of the hulls, empty hulls, light, immature oats and dust. It must not contain an excessive amount of oat hulls.

PEANUT PRODUCTS.

Peanut Oil Cake is the residue after the extraction of part of the oil by pressure or solvents from peanut kernels.

Peanut Oil Meal is the ground residue after the extraction of part of the oil from peanut kernels.

Unhulled Peanut Oil Feed is the ground residue obtained after extraction of part of the oil from whole peanuts and the ingredients shall be designated as *Peanut Meal and Hulls.*

RICE PRODUCTS.

Rice Bran is the cuticle beneath the hull.

Rice Hulls are the outer chaffy coverings of the rice grain.

Rice Polish is the finely powdered material obtained in polishing the kernel.

RYE PRODUCTS.

Rye Middlings or Rye Feed consists of the products other than the flour obtained in the manufacture of the ordinary or "100%" rye flour from the rye grain which has been cleaned and scoured.

Rye Red Dog Flour consists of a mixture of low-grade flour, fine particles of bran and the fibrous offal from the "tail of the mill."

VELVET BEAN PRODUCTS.

Velvet Bean Meal is ground velvet beans containing only an unavoidable trace of hulls or pods.

Ground Velvet Bean and Pod is the product derived by grinding velvet beans "in the pod." It contains no additional pods or other materials.

WHEAT PRODUCTS.

Wheat Bran is the coarse outer coating of the wheat kernel as separated from cleaned and scoured wheat in the usual process of commercial milling.

Standard Middlings (Red Shorts or Brown Shorts) consists mostly of the fine particles of bran, germ and very little of the fibrous offal obtained from the "tail of the mill." This product must be obtained in the usual commercial process of milling.

Gray Shorts (Gray Middlings or Total Shorts) consists of the fine particles of the outer bran, the inner or "bee-wing" bran, the germ, and the offal or fibrous material obtained from the "tail of the mill." This product must be obtained in the usual process of commercial milling.

Flour Middlings shall consist of standard middlings and red dog flour combine in the proportions obtained in the usual process of milling.

White Shorts or White Middlings consists of a small portion of the fine bran particles and the germ and a large portion of the fibrous offal obtained from the "tail of the mill." This product must be obtained in the usual process of flour milling.

Red Dog Flour consists of a mixture of low-grade flour, fine particles of bran and the fibrous offal from the "tail of the mill."

Wheat Mixed Feed (Mill Run Wheat Feed) consists of pure wheat bran and the gray or total shorts or flour middlings combined in the proportions obtained in the usual process of commercial milling.

Wheat Bran and Standard Middlings consists of the two commodities as defined above mixed in the proportions obtained in the usual process of commercial milling.

Screenings consists of the smaller imperfect grains, weed seeds and other foreign materials, having feeding value, separated in cleaning the grain.

Scourings consists of such portions of the cuticle, brush, white caps, dust, smut, and other materials as are separated from the grain in the usual commercial process of scouring.

(*Note*) If to any of the wheat or rye by-product feeds there should be added screenings or scourings, as above defined, either ground or unground, bolted or unbolted, such brand shall be so registered, labeled and sold as clearly to indicate this fact. The word "Screenings" or "Scourings" as the case may be, shall appear as a part of the name or brand and shall be printed in the same size and face of type as the remainder of the brand name. When the word "Screenings" appears it is not necessary to show also on the labeling the word "Scourings."

MISCELLANEOUS PRODUCTS.

Dried Beet Pulp is the material obtained by drying the residue from sugar beets which have been cleaned and freed from crowns, leaves and sand and which have been extracted in the process of manufacturing sugar.

Cocoanut Oil Meal ("Copra Oil Meal") is the ground residue from the extraction of part of the oil from the dried meat of the cocoanut.

Ivory Nut Meal is ground ivory nuts.

Palm Kernel Oil Meal is the ground residue from the extraction of part of the oil by pressure or solvents from the kernel of the fruit of Elaeis guineensis or Elaeis malanococoa.

Yeast or Vinegar Dried Grains are the properly dried residue from the mixture of cereals, malt and malt sprouts (sometimes cottonseed meal) obtained in the manufacture of yeast or vinegar, and consists of corn or corn and rye from which most of the starch has been extracted, together with malt added during the manufacturing process to change the starch to sugars, and malt sprouts (sometimes cottonseed meal) added during the manufacturing pro-

cess to aid in filtering the residue from the wort and serve as a source of food supply for the yeast.

TENTATIVE DEFINITIONS.

41.12 Per Cent Protein Cottonseed Meal, Choice Quality, must be finely ground, not necessarily bolted, perfectly sound and sweet in odor, yellow, free from excess of lint, and by analysis must contain at least 41.12 per cent crude protein equivalent to 8 per cent of ammonia.

Cottonseed Meal not fulfilling the above requirements as to color, odor or texture, shall be branded Off Quality.

38.56 Per Cent Protein Cottonseed Meal, Prime Quality, must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, yellow, not brown reddish, free from excess of lint, and by analysis must contain at least 38.56 per cent crude protein, equivalent to 7½ per cent of ammonia.

Cottonseed Meal not fulfilling the above requirements as to color, odor or texture, shall be branded Off Quality.

36 Per Cent Protein Cottonseed Meal, Good Quality, must be finely ground, not necessarily bolted, of sweet odor, reasonably bright in color, and by analysis must contain at least 36 per cent crude protein, equivalent to 7 per cent of ammonia.

Cottonseed Meal not fulfilling the above requirements as to color, odor or texture, shall be branded Off Quality.

Fish Meal shall be the dried, ground tissues of fish made from undecomposed fish, with or without the extraction of part of the oil.

Fish Residue Meal shall be the clean undecomposed residue from the manufacture of glue or other fishery products and to be from non-oily fish.

Maltrose Process Corn Gluten Feed is the dried residue from degermed corn, after removal of starch in the manufacture of malt syrup.

Ground Barley is the entire product obtained by grinding clean sound barley, containing not less than 90 per cent pure barley and not more than 10 per cent of other grains, weed seeds and other foreign material and not more than 6 per cent fiber. Provided that no portion of this stated 10 per cent of other grains, weed seeds or foreign material shall be deliberately added.

Mixed Feed Barley is the entire product obtained by grinding country run barley containing not less than 75 per cent pure barley and not more than 25 per cent other grains, weed seeds and other foreign material. Provided that no portion of this stated 25 per cent of other grains, weed seeds or foreign material shall be deliberately added. The ingredients must be stated as barley other grains, weed seeds and other foreign material.

Rice Bran is the pericarp or bran layer of the rice grain, with only such quantity of hull fragments as is unavoidable in the regular milling of rice.

Chopped Alfalfa is the entire alfalfa hay, chopped and not ground finely enough to become a meal. It must not contain an admixture of alfalfa straw or other foreign material.

Ear Corn Chops is corn and cob, chopped, without the husk, with not a greater proportion of cob than occurs in the ear corn in its natural state.

Head Chops consists of the entire head of the grain sorghums, chopped, and should bear the name of the sorghum from which it is made. This includes, among others, kafir head chops, milo head chops, feterita head chops, and sorghum head chops.

Head Stems consists of the head of the grain sorghums, from which the grain has been removed, and should bear the name of the sorghum from which it is made.

RESOLUTIONS ADOPTED.

Resolved, That it is the sense of this Association that we understand the term ''Nitrogen Free Extract'' to cover the product indicated by the percentage obtained by subtracting from 100 per cent the sum of the percentages of Ash, Moisture, Protein, Fat and Fiber.

Resolved, That the term ''Carbohydrates'' be interpreted to cover the product indicated by the percentage obtained by the addition of the percentages of crude fiber and nitrogen free extract.

Resolved, That this Association goes on record as condemning the practice of the packing of cottonseed meal and other feeds in bags containing 99 lbs. net, and billing and charging for the same 100 lbs. net.

Resolved, That it is the sense of this Association that a ton of feed be 2,000 pounds, net.

PROPOSED STANDARDS FOR WHEAT MILL FEEDS.

	Protein (Min)	Fat (Min)	Fiber (Max)
Standard Middlings	16.0 per cent	4.5 per cent	9.0 per cent
Flour Middlings	15.0 per cent	3.0 per cent	6.0 per cent
Red Dog Flour	16.0 per cent	4.5 per cent	4.0 per cent
Brown Shorts	15.5 per cent	3.5 per cent	6.5 per cent
Gray Shorts	16.0 per cent	3.5 per cent	5.5 per cent
White Shorts	14.5 per cent	3.0 per cent	3.5 per cent
Wheat Mixed Feed	15.5 per cent	3.5 per cent	8.5 per cent

STOCK AND POULTRY "CONDITIONERS."

During the past year we have examined a number of so-called stock and poultry conditioners or tonics. While these do not come under the jurisdiction of the feeding stuffs law it was felt that the matter was of sufficient importance to examine, more or less thoroughly, all samples coming to our attention. Most of the samples were sent to the laboratory by residents of the State and a few were collected by the inspectors. In most of the cases the ingredients have simply been identified with no attempt made to estimate the quantity of each. In those samples that consist largely of mineral salts a fairly complete analysis has been made.

From an examination of the ingredients found in these various preparations it will be possible for a person to form a very good estimate of their value, especially, if it is remembered that such materials as cocoa shells, peanut shells and buckwheat hulls have very little feeding value, and, so far as is known, no medicinal or tonic value. In many cases these materials constitute the major part of the preparation.

A list of the preparations examined and the results obtained is given below—

''SAL-TONIK''

Manufactured by the Guarantee Veterinary Co., Chicago, Ill., and Sioux City, Ia. This preparation is marketed in the form of blocks weighing 50 lbs. each. The analysis of a sample submitted by Henry Ver Hulst, Hamilton, Michigan follows:—

Sodium Chloride (Salt)	94.20%
Sodium Sulfate (Glauber's Salt)	1.89%
Sodium Bicarbonate	0.30%
Magnesium Sulfate (Epsom Salt)	1.20%
Calcium carbonate	0.84%
Organic Matter	0.34%
Insoluble Mineral Matter	1.19%

The insoluble matter contained free sulfur and oxide of iron which was not determined.

A second sample submitted by O. M. Wallace, Burton, Mich., contained 96.65 per cent salt.

"DOZ-IT."

Manufactured by the Farmers' Medicated Stock Salt Co., Mifflinburg, Pa. Sample submitted by Anthony Fenis, Westphalia, Mich.

Sodium Chloride (Salt)	94.25%
Charcoal	3.58%

Traces of Magnesium Sulfate (Epsom Salt) and ferrous Sulfate (Copperas).

A second sample submitted by the Gladstone Grocery, Gladstone, Mich., gave the following snalysis:

Sodium Chloride (Salt)	94.95%
Charcoal	2.87%

"FEDERAL STOCK CONDITIONER."

Manufactured by the Federal Stock Food Co., Mifflinburg, Pa. Sample submitted by D. L. Hagerman, Grand Rapids, Mich.

The following ingredients were identified: Cocoa shell meal, buckwheat hulls, peanut shells, oyster shells, salt, calcium carbonate and traces of copperas, mustard and red peper.

"EMPIRE STOCK CONDITIONER."

Manufactured by the Capitol Food Co., New York City. Sample submitted by John C. Liken Co., Sebewaing, Mich.

The following materials have been identified: Cocoa shells, peanut shells and meal, buckwheat hulls, oyster shells, sulfur, ferrous sulfate (copperas) and traces of magnesium sulfate (Epsom Salt), gentian, sassafras, anise, capsicum and mica.

"EMPIRE POULTRY CONDITIONER"

Manufactured by the Capitol Food Co., New York City. Sample submitted by John C. Liken Co., Sebewaing, Mich. The following materials were identified: Cocoa shells, peanut shells, buckwheat hulls, oyster shells (25%), sulfur, charcoal, copperas and traces of mustard, sassafras bark, fenurgreek, anise, black pepper, mica.

"MOORMAN'S MINERAL MIXTURE."

Manufactured by Moorman Manufacturing Co., Quincy, Ill. Sample submitted by Otto B. Schulze, Nashville, Mich.

The following materials were identified: Sodium sulfate (Glauber's salt), rock phosphate, sulfur, charcoal and trace of copperas. The ingredients are present in about the following proportions:

Glauber's Salt	45.70%
Rock phosphate	24.02%
Sulfur	7.15%
Charcoal and sand	23.13%
Copperas	trace

"DR. HESS' STOCK TONIC."

Manufactured by Drs. Hess & Clark, Ashland, Ohio. Sample submitted by Inspector Teske. The following ingredients were identified: Salt (42.43%), epsom salt, glauber's salt, potassium nitrate (salt peter) copperas, quassia, fenurgreek, nux vomica, wheat bran, charcoal.

"GUARDIAN STOCK CONDITIONER."

Manufactured by the Guardian Food Company, New York City and Indianapolis, Ind. Sample submitted by C. M. Kidman, Port Huron, Mich.

Ingredients identified: Peanut shells, charcoal, fenurgreek, quassia, salt, copperas, Glauber's salt, sulfur.

The ingredients are present in approximately the following proportions:

Sodium chloride (salt)	66.47%
Sulfur	0.71%
Sodium Sulfate (Glauber's Salt) Ferrous Sulfate (Copperas)	10.17%
Peanut Shells Charcoal	22.65%

ANALYSES OF FEEDING STUFFS FOR 1920-1921.

Laboratory number.	Manufacturer and trade name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	COTTONSEED MEAL						
	American Cotton Oil Co., New York City						
		G.†	......	*36.0*	*5.5*	*14.0*	
B 6218	Surety Brand Cottonseed Meal	Grand Rapids... F.†	8 0	37.4	7.9	10.5	$45 00
B 6219	Surety Brand Cottonseed Meal	Grand Rapids	8 9	34.2	7 0	12.7	45 00
B 6224	Surety Brand Cottonseed Meal	Grand Rapids	8 9	36.6	7.6	11.3	46 00
B 6303	Surety Brand Cottonseed Meal	Howell	8.4	39.6	9.3	8.2	2 30
		Average	8.6	37.0	8 0	10.7	
	American Milling Co., Peoria, Ill.						
		G.†	......	*41.0*	*6.0*	*12.0*	
B 6183	AMCO Cottonseed Meal	Nunica .... F.†	9.2	41.8	7.7	8.9	58 00
B 6237	AMCO Cottonseed Meal	Zeeland	8.8	40 4	6.6	11.9	40 00
		Average	9.0	41.1	7.2	10.4	
	The J. E. Bartlett Co., Jackson, Mich.						
		G.†	......	*41.0*	*5.0*	*14.0*	
B 5934	Farmer Brand Cottonseed Meal	Washington..... F.†	9.0	42.4	7.6	9.4	....
B 5937	Farmer Brand Cottonseed Meal	Ann Arbor	8.5	43 1	7.9	10.0	....
		Average	8.8	42.8	7.8	9.7	
		G.†	......	*43.0*	*7.0*	*10.0*	
B 5909	Farmer Brand Choice Cottonseed Meal	Carleton .... F.†	8.6	39.2	7.8	12.4	68 00
B 5910	Farmer Brand Choice Cottonseed Meal	Manchester	8.3	42.5	6.8	10.9	....
B 5927	Farmer Brand Choice Cottonseed Meal	Fowlerville	8 3	44.5	7.2	9.8	....
B 5942	Farmer Brand Choice Cottonseed Meal	Rochester	6.9	44.6	9.2	7.1	6 00
B 5949	Farmer Brand Choice Cottonseed Meal	Romeo	8.9	42.4	7.5	10.9	65 00
B 5950	Farmer Brand Choice Cottonseed Meal	Romeo	7.5	45.0	7 7	6.6	65 00
B 5953	Farmer Brand Choice Cottonseed Meal	Pinckney	6.8	45.7	7 2	7 6	63 00
B 5968	Farmer Brand Choice Cottonseed Meal	Linden	8.9	42.0	7.4	11.1	3 50
B 5987	Farmer Brand Choice Cottonseed Meal	Saginaw	7.9	45 6	11.6	7.1	....
B 5988	Farmer Brand Choice Cottonseed Meal	Birch Run	7.9	46.2	7.3	7.1	56 00
B 5991	Farmer Brand Choice Cottonseed Meal	Cass City	8.4	46 8	7.2	8 0	60 00
B 6021	Farmer Brand Choice Cottonseed Meal	Bay City	12.3	46 3	8 2	4.7	58 00
B 6063	Farmer Brand Choice Cottonseed Meal	Mt. Clemens	8.3	45.6	7.8	8.8	60 00
B 6097	Farmer Brand Choice Cottonseed Meal	St. Johns	7.9	44.5	6 2	9.5	55 00
B 6241	Farmer Brand Choice Cottonseed Meal	Zeeland	8.1	42.5	6.0	10 5	....
B 6413	Farmer Brand Choice Cottonseed Meal	Union City	8.0	44.3	8.7	7.6	2 50
		Average	8.3	44.2	7.7	8.7	
		G.†	......	*38.6*	*5.0*	*18.0*	
B 6242	Farmer Brand Prime Cottonseed Meal	Zeeland......... F.†	8.9	40.6	7.9	11.7	40 00
		G.†	......	*36.0*	*5.0*	*17.0*	
B 5973	Farmer Brand "Straight" Cottonseed Meal	Milford......... F.†	8.0	37.0	7.0	10.5	5 50
	T. O. Branch Company, Little Rock, Ark.						
		G.†	......	*36.0*	*6.0*	*12.0*	
B 6103	Holstein Brand Cottonseed Meal	Croswell........ F.†	8.2	39.8	7.3	8.1	....
	F. W. Brode & Company, Memphis, Tenn.						
		G.†	......	*36.0*	*5.6*	*14 0*	
B 6127	Jay Brand Cottonseed Meal	Grand Rapids... F.†	8.8	39.0	9.0	10.2	....
		G.†	......	*43.0*	*6.0*	*9.0*	
B 5952	Ordinary Cottonseed Meal	Thomas........ F.†	8.2	40.0	6.5	12.7	70 00
	The Buckeye Cotton Oil Co., Cincinnati, Ohio						
		G.†	......	*36.0*	*5.0*	*14.0*	
B 5917	"Buckeye" Good Cottonseed Meal	Lansing......... F.†	7 6	36.9	7.5	9.9	62 00
B 5992	"Buckeye" Good Cottonseed Meal	Ubly	10.4	35.0	6 3	14 6	55 00
B 6030	"Buckeye" Good Cottonseed Meal	Bay City	7 6	35 9	8.4	11.1	....
B 6043	"Buckeye" Good Cottonseed Meal	Parma	8 2	35 7	6 8	12.2	....
		Average	8.5	35.9	7.3	12.0	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920–1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	COTTONSEED MEAL.—Continued.						
	Dallas Peanut Feed Mfgrs., Dallas, Texas						
		G.†	......	*43 0*	*5.0*	*12 0*	
B 5941	Besfeed Cottonseed Meal and Cake..............	Walled Lake.... F.†	8.1	44 9	7 4	8.9	$59 00
B 6003	Besfeed Cottonseed Meal and Cake..............	Albion..............	9 2	46 2	7.8	8.1	55 00
B 6017	Besfeed Cottonseed Meal and Cake..............	Saline	8.7	45.1	9.3	6 8	....
B 6139	Besfeed Cottonseed Meal and Cake..............	Decatur	8.1	48.5	7.1	7.1	....
B 6204	Besfeed Cottonseed Meal and Cake..............	Trufant..............	7.4	46.9	9.3	6 6	58 00
B 6208	Besfeed Cottonseed Meal and Cake..............	Kalamazoo...........	6.3	51.3	8.9	4.8	48.00
		Average...........	8.0	47.2	8.3	7.1	
	S. P. Davis, Little Rock, Ark.						
		G.†	......	*36 0*	*6.0*	*14.0*	
B 6096	Beauty Cottonseed Meal..........................	Ann Arbor...... F.†	8 3	35.9	7.2	11.6	46 00
B 6386	Beauty Cottonseed Meal..........................	Jackson..............	7.9	38.2	7.4	9.6	....
		Average...........	8.1	37.1	7.3	10.6	
		G.†	......	*41.0*	*6.0*	*1,.0*	
B 5960	Goodluck Cottonseed Meal.......................	Milan.......... F.†	7.1	41.6	8.8	7.1	60 00
		G.†	......	*43.0*	*6.0*	*1,.0*	
B 5959	Steerboy Cottonseed Meal........................	Willis.......... F.†	7.8	42.8	8 6	9.7	67.00
B 5961	Steerboy Cottonseed Meal........................	Ida..................	7.0	46.6	7.4	7.5	4 00
		Average...........	7.4	44.7	8.0	8.6	
	East St. Louis Cotton Oil Co., Chicago, Ill.						
		G.†	......	41.0	*6,0*	*12.0*	
B 6505	Illinois Brand Cottonseed Meal...................	Battle Creek.... F.†	6.7	44.1	7.9	6.3	43 00
B 6414	Illinois Brand Cottonseed Meal...................	Springport............	7.6	41.8	8.1	7.1	....
		Average...........	7.2	43.0	8.0	6.7	
		G.†	......	*36 0*	*5.0*	*16.0*	
B 5905	St. Clair Brand Cottonseed Meal	Almont .... F.†	8.8	37.3	6.7	13.2	....
B 5906	St. Clair Brand Cottonseed Meal.................	Howell	8.6	39.3	8 0	11.4	70 00
B 5925	St. Clair Brand Cottonseed Meal.................	Williamston...........	9 9	36 8	6.5	14 0	70 00
B 5964	St. Clair Brand Cottonseed Meal.................	Hillsdale..............	8 9	36 4	5 8	15 7	63 00
B 6004	St. Clair Brand Cottonseed Meal.................	Albion................	9 7	36 9	6 6	13.8	50 00
B 6045	St. Clair Brand Cottonseed Meal.................	Owosso..............	9.1	38 2	7.6	11.8	1.90
B 6074	St. Clair Brand Cottonseed Meal.................	Birmingham...........	8 9	38.4	7.9	12.3	50 00
B 6091	St. Clair Brand Cottonseed Meal.................	Ann Arbor	9 8	37.4	6.7	7.6	....
B 6220	St. Clair Brand Cottonseed Meal.................	Coopersville...........	9 3	36 1	6.9	13.9	50 00
B 6236	St. Clair Brand Cottonseed Meal.................	Grandville............	9 3	35.4	6 6	12.9	52 00
B 6247	St. Clair Brand Cottonseed Meal.................	Muskegon............	7.9	36.1	7.3	11.6	40 00
		Average...........	9.1	37.1	7.0	12.6	
	Fidelity Products Co, Houston, Texas						
		G.†	......	*43.0*	*6 0*	*12.0*	
B 5955	Fidelity Cottonseed Meal.........................	Ann Arbor...... F.†	7.6	44.9	7.1	8.8	58 00
B 5956	Fidelity Cottonseed Meal.........................	Ypsilanti............	7 0	44.5	8.4	9.2	58 00
B 5957	Fidelity Cottonseed Meal.........................	Ypsilanti............	7.0	46 4	8.4	7.9	58 00
B 5958	Fidelity Cottonseed Meal.........................	Willis................	6.9	46.4	7.4	7.5	58 00
B 5962	Fidelity Cottonseed Meal	Ida..................	6.1	45.4	8.7	7.6	57 50
B 5967	Fidelity Cottonseed Meal.........................	Owosso..............	7.6	45.4	7.2	8.0	56 00
B 5971	Fidelity Cottonseed Meal.........................	Holly................	7.5	42.3	6.8	9.9	60 00
B 5977	Fidelity Cottonseed Meal.........................	Monroe..............	8.5	44 5	8 0	7.1	57 00
B 5978	Fidelity Cottonseed Meal.........................	Ida	7.9	45.8	7.2	7.8	60 00
B 5979	Fidelity Cottonseed Meal.........................	Milan................	7.3	44.7	8.1	8.2	56 00
B 5980	Fidelity Cottonseed Meal.........................	St. Clair.............	8.8	40.5	13.3	7.8	57 00
B 5982	Fidelity Cottonseed Meal.........................	Azalia...............	7.0	43.7	7.3	8.4	56 00
B 5983	Fidelity Cottonseed Meal.........................	Milan................	7.6	45.5	7.9	7.4	56 00
B 5984	Fidelity Cottonseed Meal.........................	Onsted..............	8.4	45.8	6.6	7.2	60 00
B 5990	Fidelity Cottonseed Meal.........................	Ellington............	7.6	46.4	7.5	7.7	58 00
B 5996	Fidelity Cottonseed Meal.........................	So. Rockwood.........	7.5	47.7	8.2	7.0	....
B 6002	Fidelity Cottonseed Meal.........................	Pittsford.............	8.2	43.6	7.7	8.0	....
B 6059	Fidelity Cottonseed Meal.........................	St. Clair.............	9.0	40.7	12.7	10.9	56 00
B 6152	Fidelity Cottonseed Meal.........................	Marcellus............	6.9	45.4	8.3	7.4	60 00
B 6154	Fidelity Cottonseed Meal.........................	Cassopolis...........	6 9	45.6	7 1	8.5	....
B 6163	Fidelity Cottonseed Meal.........................	Conklin..............	9.3	46 4	7.0	6.3	....
B 6202	Fidelity Cottonseed Meal.........................	Grand Ledge..........	8.1	46.3	7.5	6 6	60 00
B 6145	Fidelity Cottonseed Meal.........................	Amble................	6 7	44.4	8.7	9.5	....
B 6146	Fidelity Cottonseed Meal.........................	Amble................	6.5	44.1	10.2	8.7	....
		Average...........	7.6	44.9	8.2	8.1	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	COTTONSEED MEAL.—Continued.						
	John H. Hailey Co., Houston, Texas						
		G.†	......	*43 0*	*5.0*	*12.0*	
B 5902	Texas Brand Cottonseed Meal 43%	Caro F.†	9 0	44 0	6 6	9.2	$69 00
B 5904	Texas Brand Cottonseed Meal 43%	Fairgrove	8.8	43 3	6.5	9.1	69 00
B 6035	Texas Brand Cottonseed Meal 43%	Akron	7.9	44 4	8 0	9.1	55 00
B 6105	Texas Brand Cottonseed Meal 43%	Augusta	6.9	46 8	7.9	7.3	75.00
B 6382	Texas Brand Cottonseed Meal 43%	Morenci	8.5	44.9	7.4	7.6	42 00
		Average	8.2	44 7	7.3	8 5	
	Hales & Hunter Co., Chicago, Ill.						
		G.†	......	*36 0*	*5 0*	*14 0*	
B 6176	Cottonseed Meal	Grand Rapids F.†	9 0	45.3	7.5	9.1	50.00
	Hayes Grain & Commission Co., Chicago, Ill.						
		G.†	......	*36.0*	*5.0*	*14 0*	
B 5901	Arkansaw Brand Cottonseed Feed	Grass Lake F.†	8 8	40 2	8 2	11.0	65 50
B 5954	Arkansaw Brand Cottonseed Feed	Pinckney	7 8	34 3	8 4	13.1	....
B 5965	Arkansaw Brand Cottonseed Feed	Quincy	6 4	35 3	8.3	12.0	60.00
B 5975	Arkansaw Brand Cottonseed Feed	Milford	8 0	35 7	6 0	13.5	2 50
B 5989	Arkansaw Brand Cottonseed Feed	Vassar	8 8	37 9	8 1	10 8	....
B 5994	Arkansaw Brand Cottonseed Feed	Bad Axe	8.8	35 6	6 5	12.0	....
B 6005	Arkansaw Brand Cottonseed Feed	Parma	8 5	40 0	7.3	8 3	50 00
B 6028	Arkansaw Brand Cottonseed Feed	Bay City	7.5	37 0	6 5	13 0	....
B 6070	Arkansaw Brand Cottonseed Feed	Mason	7 8	36 7	6 8	10 6	40 00
B 6118	Arkansaw Brand Cottonseed Feed	Allegan	7 7	35 7	6 1	14 0	72 00
B 6180	Arkansaw Brand Cottonseed Feed	Hudsonville	9 0	41 5	8 2	7.2	60 00
B 6253	Arkansaw Brand Cottonseed Feed	Hudsonville	8 2	38 9	6 9	8.6	55 00
B 6272	Arkansaw Brand Cottonseed Feed	Big Rapids	8 6	38 5	7.5	9.1	53 00
B 6399	Arkansaw Brand Cottonseed Feed	Harbor Beach	8.1	35.8	9 0	11.9	....
		Average	8.1	37.4	7.4	11.1	
		G.†	......	*43.0*	*6.5*	*9.5*	
B 6019	Hayes Brand, Cottonseed Meal and Cake	Salzburg F.†	7.6	45.8	8.0	5 9	2 75
B 6084	Hayes Brand, Cottonseed Meal and Cake	Pontiac	6.9	47.9	11.1	4.2	50 00
		Average	7.3	46.9	10.0	5.1	
		G.†	......	*38.6*	*6 0*	*12 0*	
B 5918	Supreme Brand Cottonseed Meal	Lansing F.†	7.5	40.7	7.8	12.3	
	Humphreys Godwin Co., Memphis, Tenn.						
		G.†	......	*43 0*	*5.0*	*10 0*	
B 6408	Bull Brand Cottonseed Meal	Brown City F.†	7.8	43.9	8.1	7.7	....
	Imperial Cotton Sales Co., Chicago, Ill.						
		G.†	......	*41.0*	*6 0*	*8.0*	
B 6088	Imperial Cotto Brand Choice Cottonseed Meal	Wayne F.†	8 2	41 6	8 0	7 2	47 00
B 6151	Imperial Cotto Brand Choice Cottonseed Meal	Three Rivers	7.7	41.8	8.3	8.3	....
		Average	8.0	41.7	8.2	7.8	....
		G.†	......	*43.0*	*5.0*	*16.0*	
B 6090	Silo Brand Cottonseed Meal or Cake	Ann Arbor F.†	7.6	46.9	7.5	6.7	47 00
	Industrial Cotton Oil Properties, New York City						
		G.†	......	*43.0*	*6.0*	*12.0*	
B 5969	Longhorn Brand Prime Cottonseed Meal	Fenton F.†	7 0	43.0	8 2	7.4	....
B 5976	Longhorn Brand Prime Cottonseed Meal	Trenton	7.9	43.3	7.7	10.2	....
		Average	7.5	43.2	8.0	8.8	
	Italy Cotton Oil Co., Italy, Texas						
		G.†	....	*43.0*	*6.0*	*12 0*	
B 6524	Ordinary Cottonseed Meal	Plainwell F.†	8.4	44.6	10.0	5 6	44 00
	Larrowe Milling Company, Detroit, Mich.						
		G.†	......	*43.0*	*6.0*	*10.0*	
B 5985	Larrow Brand Choice Cottonseed Meal	Okemos F.†	8.2	43.7	8 2	9.9	3.50
B 6409	Larrow Brand Choice Cottonseed Meal	Lapeer	8.8	44.8	7.6	8.0	....
		Average	8.5	44.3	7.9	9.0	
	L. B. Lovitt & Co., Memphis, Tenn.						
		G.†	......	*43.0*	*6.0*	*10.0*	
B 6375	"Neal's Choice" Cottonseed Meal	Coldwater F.†	8.2	46.3	8.2	7.5	....

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	COTTON SEED MEAL.—Continued.						
	L. B. Lovitt & Co.—Concluded.	G.†	......	*36.0*	*5.0*	*14.0*	
B 5938	Thirty-Six Brand Cottonseed Meal	Mason F.†	7.6	35.0	6.7	13.1	$55.00
B 5946	Thirty-Six Brand Cottonseed Meal	New Haven	7.5	39.2	8.5	8.4	70.00
B 6066	Thirty-Six Brand Cottonseed Meal	Leslie	8.0	36.7	7.4	11.5	2.25
B 6243	Thirty-Six Brand Cottonseed Meal	Zeeland	8.5	36.7	6.8	10.3	40.00
		Average	7.9	36.9	7.4	10.8	
	C. L. Montgomery & Co., Memphis, Tenn.	G.†	......	*36.0*	*6.0*	*14.0*	
B 6525	Star Brand Cottonseed Meal	Plainwell F.†	10.0	37.3	6.3	12.6	40.00
	W. C. Nothern, Memphis, Tenn.	G.†	......	*41.0*	*6.0*	*12.0*	
B 6275	Bee Brand Cottonseed Meal	Grand Rapids F.†	8.2	42.0	8.7	4.9	41.00
		G.†	......	*43.0*	*65.0*	*10.0*	
B 5903	Queen Bee Brand Cottonseed Meal	Caro F.†	7.4	44.9	6.7	9.8	70.00
B 5986	Queen Bee Brand Cottonseed Meal	Lansing	6.5	43.9	8.7	7.3	......
B 6197	Queen Bee Brand Cottonseed Meal	Brunswick	7.4	43.1	7.7	5.3	55.00
		Average	7.1	43.9	7.7	7.5	
		G.†	......	*36.0*	*5.0*	*12.0*	
B 6213	Standard Brand Cottonseed Meal	Zeeland F.†	8.8	36.7	6.7	13.6	50.00
	Ryan Cotton Oil Co., Ryan, Okla.	G.†	......	*43.0*	*5.0*	*10.0*	
B 6158	Prime Cottonseed Meal and Cake	Niles F.†	7.8	43.4	8.4	10.5	......
	J. M. Sansom & Co., Dallas, Texas	G.†	......	*36.0*	*5.0*	*19.0*	
B 5966	Sansom's 36 Cottonseed Meal	Owosso F.†	7.2	35.2	8.3	12.3	55.00
	Southland Cotton Oil Co., Paris, Texas	G.†	......	*43.0*	*6.0*	*12.0*	
B 5972	Climax Brand Cottonseed Cake or Meal	Davisburg F.†	7.6	42.2	8.4	9.4	62.00
B 6160	Climax Brand Cottonseed Cake or Meal	Niles	7.9	43.6	9.4	6.0	65.00
		Average	7.8	42.9	8.9	7.7	
	Texas Cake & Linter Co., Dallas, Texas	G.†	......	*45.0*	*6.0*	*10.0*	
B 5995	Higrade Brand Prime Cottonseed Cake and Meal	Fairgrove F.†	8.3	43.9	6.3	8.7	......
		G.†	......	*36.0*	*5.0*	*20.0*	
B 6150	Panhandle Brand Good Cottonseed Meal	Belmont F.†	8.1	37.5	7.9	10.8	48.00
B 6168	Panhandle Brand Good Cottonseed Meal	Grand Rapids	7.9	35.2	8.7	12.4	60.64
B 6244	Panhandle Brand Good Cottonseed Meal	Comstock Park	8.5	35.9	7.6	12.0	54.00
B 6274	Panhandle Brand Good Cottonseed Meal	Big Rapids	8.7	35.6	7.9	11.4	50.00
B 6404	Panhandle Brand Good Cottonseed Meal	Sandusky	8.3	37.6	8.2	8.4	......
		Average	8.3	36.4	8.1	11.0	
		G.†	......	*43.0*	*6.0*	*12.0*	
B 5943	Texoma Brand Prime Cottonseed Cake and Meal	New Haven F.†	7.4	45.5	8.3	7.7	67.00
B 5947	Texoma Brand Prime Cottonseed Cake and Meal	Romeo	7.2	46.9	7.6	6.9	65.00
B 6207	Texoma Brand Prime Cottonseed Cake and Meal	Greenville	7.5	46.3	8.0	7.0	60.00
		Average	7.4	46.2	8.0	7.2	
	Wagner-White Co., Jackson, Mich.	G.†	......	*43.0*	*6.0*	*9.0*	
B 5931	Waw-Co 43% Cottonseed meal	Rochester F.†	8.7	44.5	7.6	10.1	72.00
B 5932	Waw-Co 43% Cottonseed Meal	Washington	7.9	45.5	7.5	7.7	3.75
B 5963	Waw-Co 43% Cottonseed Meal	Blissfield	6.6	43.1	8.0	9.6	60.00
B 5970	Waw-Co 43% Cottonseed Meal	Fenton	7.6	43.9	9.2	9.0	3.50
B 6000	Waw-Co 43% Cottonseed Meal	Hudson	7.0	42.7	7.3	9.5	......
B 6007	Waw-Co 43% Cottonseed Meal	Rives Junction	7.5	42.7	8.4	9.1	......
B 6136	Waw-Co 43% Cottonseed Meal	Hamilton	7.6	45.0	7.8	8.3	60.00
B 6149	Waw-Co 43% Cottonseed Meal	Nashville	7.4	43.9	8.3	9.2	......
B 6383	Waw-Co 43% Cottonseed Meal	Tecumseh	7.9	45.9	7.6	6.9	60.00
B 6412	Waw-Co 43% Cottonseed Meal	Union City	8.2	41.7	7.7	9.6	45.00
		Average	7.6	43.9	7.9	8.9	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.	Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	COTTONSEED MEAL.—Continued.						
	A. C. Westervelt & Co., Memphis, Tenn.						
		G.†	......	*43.0*	*6.0*	*10.0*	
B 5936	Planet Brand Cottonseed Meal	Southfield....... F.†	8.3	46.3	8.8	8.3	$60 00
B 5993	Planet Brand Cottonseed Meal	Ubly	8.9	44.0	7.7	7.8	58 00
B 6008	Planet Brand Cottonseed Meal	Caro	7.2	45.9	6.9	6.1	....
B 6009	Planet Brand Cottonseed Meal	Port Huron	7.4	43.3	7.4	7.8	....
B 6011	Planet Brand Cottonseed Meal	Rochester	7.4	45.4	6.8	6.1	....
B 6012	Planet Brand Cottonseed Meal	Fenton	6.7	44.6	8.0	5.6	45 00
B 6018	Planet Brand Cottonseed Meal	Riga	7.2	45.7	8.1	5.0	....
B 6032	Planet Brand Cottonseed Meal	Fostoria	7.3	45.1	8.2	7.4	50 50
B 6033	Planet Brand Cottonseed Meal	Silverwood	6.7	43.5	7.7	7.0	56 00
B 6034	Planet Brand Cottonseed Meal	Deford	7.5	45.3	7.0	6.1	50 00
B 6060	Planet Brand Cottonseed Meal	Memphis	8.2	46.3	9.6	5.6	2 25
B 6135	Planet Brand Cottonseed Meal	Hamilton	8.3	44.3	7.5	7.4	64 00
B 6235	Planet Brand Cottonseed Meal	Centerville	8.8	44.1	7.5	7.4	....
B 6407	Planet Brand Cottonseed Meal	Yale	8.8	45.2	7.9	7.0	2 60
		Average	7.8	44.9	7.8	6.8	
	Willingham Warehouse Co., Dallas, Texas						
		G.†	......	*43.0*	*6.0*	*12.0*	
B 6078	Superior Brand Choice Cottonseed Meal	Pontiac......... F.†	7.5	43.4	6.5	9.4	2 50
B 6335	Superior Brand Choice Cottonseed Meal	Detroit	8.3	43.2	7.3	9.1	2 25
		Average	7.9	43.3	6.9	9.3	
	J. N. Willis Cotton Products Co., Dallas, Texas						
		G.†	......	*43.0*	*6.0*	*14.0*	
B 5944	Ordinary Cottonseed Meal	New Haven..... F.†	8.2	45.2	7.9	8.0	67 00
B 5948	Ordinary Cottonseed Meal	Romeo	8.1	43.2	7.0	8.8	65 00
B 6010	Ordinary Cottonseed Meal	Rochester	8.0	46.2	7.5	8.0	60 00
		Average	8.1	44.9	7.5	8.3	....
	E. H. Young Co., Inc., Dallas, Texas						
		G.†	......	*43.0*	*5.0*	*12.0*	
B 6014	Young's Forty-Three Prime Cottonseed Meal & Cake	Saline.......... F.†	8.7	45.8	8.9	7.1	....
B 6098	Young's Forty-Three Prime Cottonseed Meal & Cake	Jackson	8.7	44.7	7.0	7.9	2 30
B 6117	Young's Forty-Three Prime Cottonseed Meal & Cake	Wayland	7.1	44.4	7.9	7.6	71 00
B 6179	Young's Forty-Three Prime Cottonseed Meal & Cake	Hudsonville	9.1	43.1	7.9	8.8	66 00
B 6380	Young's Forty-Three Prime Cottonseed Meal & Cake	Morenci	8.3	47.1	7.6	7.4	....
		Average	8.4	45.0	7.9	7.8	
	COTTONSEED FEED						
	F. W. Brode & Co., Memphis, Tenn.						
		G.†	......	......	......	......	
B 6106	Fox Brand Cottonseed Feed	Augusta........ F.†	10.8	19.4	3.1	25.2	....
B 6107	Fox Brand Brand Cottonseed Feed	Augusta	8.7	20.1	3.8	25.4	....
		Average	9.8	19.8	3.5	25.3	
	LINSEED MEAL						
	American Linseed Co., Buffalo, N. Y.						
		G.†	......	*32.0*	*6.0*	*9.0*	
B 6025	Old Process Linseed Oil Meal	Bay City....... F.†	10.3	35.7	5.7	8.0	3 30
	American Milling Co., Peoria, Ill.						
		G.†	......	*30.0*	*5.0*	*10.0*	
B 6164	Amco Old Process Linseed Meal and Old Process Screenings Oil Feed	Conklin......... F.†	10.6	30.9	5.6	8.8	....
B 6184	Amco Old Process Linseed Meal and Old Process Screenings Oil Feed	Nunica	11.1	30.6	6.3	8.6	65 00
B 6238	Amco Old Process Linseed Meal and Old Process Screenings Oil Feed	Zeeland	10.2	32.6	5.7	8.6	50 00
B 6377	Amco Old Process Linseed Meal and Old Process Screenings Oil Feed	Morenci	10.0	31.3	5.5	9.2	....
B 6507	Amco Old Process Linseed Meal and Old Process Screenings Oil Feed	Battle Creek	10.2	32.0	5.7	8.2	45 00
		Average	10.4	31.5	5.7	8.7	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	LINSEED MEAL.—Continued.							
	Archer Daniels Linseed Co., Buffalo, N. Y.							
			G.†	.....	*31.0*	*5.0*	*10.0*	
B 6231	Pure Old Process Ground Oil Cake	Holland	F.†	9.6	30.5	7.7	8.4	$66 00
	Hirst & Bagley Linseed Co., Chicago, Ill.							
			G.†	.....	*34.0*	*6.0*	*9.0*	
B 6112	Hirst & Bigley Linseed Works Brand	Grand Rapids	F.†	8.7	34.5	5.0	8.0	70 00
B 6126	Hirst & Bigley Linseed Works Brand	Coopersville		9.4	39.3	6.6	7.7	....
B 6214	Hirst & Bigley Linseed Works Brand	Zeeland		9.3	40.0	5.8	7.7	60 00
B 6223	Hirst & Bigley Linseed Works Brand	Coopersville		9.0	38.5	6.2	7.7	50 00
B 6255	Hirst & Bigley Linseed Works Brand	Hudsonville		10.8	38.3	6.0	7.2	55 00
		Average		9.4	38.1	5.9	7.7	
	Midland Linseed Products Co., Minneapolis, Minn.							
			G.†	.....	*30.0*	*5.0*	*9.5*	
B 5926	Old Process Ground Linseed Cake	Williamston	F.†	10.5	29.6	8.0	8.0	65 00
B 5933	Old Process Ground Linseed Cake	Washington		10.2	29.5	7.8	7.2	....
B 6116	Old Process Ground Linseed Cake	Wayland		9.2	30.9	7.8	7.8	....
B 6122	Old Process Ground Linseed Cake	Allegan		8.9	30.0	7.9	8.2	75 00
B 6175	Old Process Ground Linseed Cake	Sparta		10.9	30.4	7.8	7.8	68 00
B 6384	Old Process Ground Linseed Cake	Tecumseh		9.7	29.4	8.5	8.0	....
		Average		9.9	29.9	7.9	7.8	
	Sherwin-Williams Co., Cleveland, Ohio							
			G.†	.....	*30.0*	*5.0*	*9.0*	
B 5998	S. W. C. Linseed Oil Meal	Adrian	F.†	9.0	31.5	6.3	7.7	3 00
	Spencer-Kellogg Co. & Sons, Inc., Buffalo, N. Y.							
			G.†	.....	*31.0*	*5.0*	*10.0*	
B 5945	Kellogg's Pure Old Process Oil Meal	New Haven	F.†	9.9	30.9	6.5	8.5	67 00
	The Toledo Seed & Oil Co., Toledo, Ohio							
			G.†	.....	*31.0*	*6.0*	*10.0*	
B 5930	Major Brand, Old Process Oil Meal	Fowlerville	F.†	9.9	28.9	7.2	9.3	74 00
B 5981	Major Brand, Old Process Oil Meal	Ida		10.3	32.0	6.9	7.9	57 00
B 6006	Major Brand, Old Process Oil Meal	Parma		10.3	31.1	7.6	9.3	3 50
B 6013	Major Brand, Old Process Oil Meal	Lansing		9.6	29.9	7.6	8.2	....
B 6062	Major Brand, Old Process Oil Meal	Mt. Clemens		9.4	30.7	6.4	8.2	60 00
B 6109	Major Brand, Old Process Oil Meal	Belmont		9.4	30.3	6.6	8.5	71 00
B 6188	Major Brand, Old Process Oil Meal	Petoskey		10.7	29.7	6.8	8.2	80 00
B 6192	Major Brand, Old Process Oil Meal	Petoskey		10.5	29.3	6.6	8.3	68 00
B 6239	Major Brand, Old Process Oil Meal	Zeeland		9.4	30.5	6.6	8.5	50 00
B 6302	Major Brand, Old Process Oil Meal	Howell		9.9	34.5	6.6	7.6	2 80
B 6527	Major Brand, Old Process Oil Meal	Hamilton		10.5	35.1	6.1	7.9	....
		Average		10.0	31.1	6.8	8.4	
	CORN GLUTEN FEED							
	Corn Products Refining Co., New York, N. Y.							
			G.†	.....	*23.0*	*1.0*	*8.5*	
B 5935	Buffalo Corn Gluten Feed	Washington	F.†	9.7	30.3	3.2	5.6	....
B 5940	Buffalo Corn Gluten Feed	Mason		9.0	26.3	3.9	7.3	....
B 6076	Buffalo Corn Gluten Feed	Birmingham		10.8	26.4	2.7	8.3	2 90
B 6174	Buffalo Corn Gluten Feed	Sparta		9.0	28.0	5.2	6.6	59 00
B 6258	Buffalo Corn Gluten Feed	Holland		9.8	25.8	5.4	7.0	59 00
		Average		9.7	27.4	4.1	7.0	
	The Huron Milling Co., Harbor Beach, Mich.							
			G.†	.....	*22.0*	*3.0*	*8.0*	
B 6209	Jenks Corn Gluten Feed	Kalamazoo	F.†	9.4	29.2	2.2	6.5	3 50
B 6400	Jenks Corn Gluten Feed	Harbor Beach		9.1	24.4	2.9	7.3	....
		Average		9.3	26.8	2.6	6.9	
	HOMINY FEED							
	Kellogg Toasted Corn Flake Co., Battle Creek, Mich.							
			G.†	.....	*10.0*	*6.0*	*5.0*	
B 6511	B. C. White Hominy Feed	Battle Creek	F.†	8.6	9.5	7.2	5.6	28 00
	Postum Cereal Co., Battle Creek, Mich.							
			G.†	.....	*10.0*	*6.0*	*5.0*	
B 6520	Burt's Hominy Feed	Battle Creek	F.†	8.7	10.6	6.4	3.8	32 00

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	CORN FEED MEAL							
	Amendt Milling Co., Monroe, Mich.							
			G.†	......	*8.5*	*2.5*	*6.5*	
B 6371	"Amco" Corn Feed Meal	Monroe	F.†	10.8	9.6	4.2	2.8	$24 00
	Armour Grain Co., Battle Creek, Mich.							
			G.†	......	*7.0*	*0.5*	*1.5*	
B 6299	Corn Feed	Battle Creek	F.†	6.5	10.0	1.8	1.1	30 00
	Commercial Milling Co., Detroit, Mich.							
			G.†	......	*9.0*	*5.0*	*1.5*	
B 6362	Henkel's Coarse Feed Corn Meal	Detroit	F.†	11.2	9.9	5.2	3.2	....
	Hankey Milling Co., Petoskey, Mich.							
			G.†	......	*9.7*	*5.0*	*3.4*	
B 6190	Corn Feed Meal	Petoskey	F.†	13.6	9.4	3.5	2.0	40 00
	Saginaw Milling Co., Saginaw, Mich.							
			G.†	......	*10.0*	*6.0*	*7.0*	
B 5914	Corn Feed Meal	Saginaw	F.†	11.4	11.4	6.2	3.7	48 00
	David Stott Flour Mills Co., Detroit, Mich.							
			G.†	......	*8.5*	*3.5*	*4.0*	
B 6355	Corn Feed Meal	Detroit	F.†	12.6	10.3	6.4	3.7	....
	Watson Higgins Milling Co., Grand Rapids, Mich.							
			G.†	......	*9.5*	*5.0*	*8.0*	
B 6171	Corn Feed	Grand Rapids	F.†	13.0	9.2	3.5	2.3	42 00
B 6198	Corn Feed	Grand Rapids		12.6	9.2	3.7	2.3	....
		Average		12.8	9.2	3.6	2.3	
	ANIMAL BY-PRODUCTS							
	Armour Fertilizer Works, Chicago, Ill.							
			G.†	......	*55.0*	*6.0*	*2.0*	
B 6086	Armour's Meat Scraps Medium Meat Residue	Pontiac	F.†	6.6	61.3	9.4	2.5	6 75
	E. H. Bok & Dr. Tacoma, Hudsonville, Mich.							
			G.†	......	......	......	......	
B 6502	Tankage	Hudsonville	F.†	8.7	50.4	14.7	1.0	....
	Chicago Feed & Fertilizer Co., Chicago, Ill.							
			G.†	......	*60.0*	*2.0*	*3.0*	
B 6245	Magic Brand Meat Scraps	Comstock Park	F.†	6.7	53.3	9.2	1.7	4 75
	Darling & Company, Chicago, Ill.							
			G.†	......	*20.0*	*0.5*	*3.0*	
B 6128	Darling's Granulated Bone	Grand Rapids	F.†	7.6	25.7	3.0	1.4	....
			G.†	......	*50.0*	*.05*	*3.0*	
B 6129	Darling's Meat Scraps	Grand Rapids	F.†	9.5	51.3	8.2	2.8	....
	Grand Ledge Rendering Co., Grand Ledge, Mich.							
			G.†	......	*40.0*	*15.5*	*3.0*	
B 6203	Tankage	Grand Ledge	F.†	6.7	41.9	16.2	1.7	....
	Hartman Tankage Works, Grand Rapids, Mich.							
			G.†	......	*49.2*	*9.8*	*0.8*	
B 6286	Tankage	Grand Rapids	F.†	7.9	53.1	12.3	0.8	4 50
	Morris & Company, Chicago, Ill.							
			G.†	......	*60.0*	*6.0*	*5.0*	
B 6526	Big Sixty Meat Meal Digester Tankage	Buchanan	F.†	10.2	59.9	5.7	1.4	....
	J. L. & H. Stadler Rendering & Fertilizer Co. Cleveland, Ohio							
			G.†	......	*60.0*	*1.0*	*4.0*	
B 5997	Stadler's 60% Digester Tankage	Adrian	F.†	11.3	63.4	5.6	1.6	4 90
	Standard Chemical Corp., Kalamazoo, Mich.							
			G.†	......	......	......	......	
B 6521	Standard Tankage	Kalamazoo	F.†	6.5	27.6	16.3	1.3	....

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.
	ANIMAL BY-PRODUCTS—Continued.							
	Wilson & Co., Chicago, Ill.							
			G.†	......	*60.0*	*6.0*	*5.0*	
B 6015	Red "W" Brand Protein Tankage........	Saline	F.†	6.7	57.4	8.0	6.4	....
	ALFALFA MEAL							
	The Albert Dickinson Co., Chicago, Ill.							
			G.†	......	*12.0*	*1.0*	*35.0*	
B 6046	Alfalfa Meal..............................	Owosso........	F.†	9.1	16.4	1.3	28.8	$2.50
	Chas. A. Krause Milling Co., Milwaukee, Wis.							
			G.†	......	*14.0*	*1.0*	*30.0*	
B 6317	Badger Alfalfa Meal........................	Detroit	F.†	9.5	15.2	1.6	27.5	2.50
	Triangle Milling Co., Kansas City, Mo.							
			G.†	......	*14.0*	*1.5*	*30.0*	
B 6390	Trifalfa Meal..............................	Jackson........	F.†	10.0	18.8	1.9	24.4	....
	H. P. Zwemer & Son, Holland, Mich.							
			G.†	......	......	......	......	
B 6259	Alfalfa Meal..............................	Holland	F.†	11.1	16.9	1.5	24.6	....

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	CALF MEAL.								
	American Milling Company, Peoria, Ill.								
B 6143	Sucrene Calf Meal	Conklin	*G.*†	......	*20 0*	*4 0*	*3 0*		Linseed meal, corn meal, wheat middlings, bone meal, blood flour, dried buttermilk, soluble starch, malt flour.
			F.†	9.6	19.3	4 5	5.0	....	
	Arcady Farms Milling Co., Chicago, Ill.								
B 6397	Arcady Calf Meal	Ypsilanti	*G.*†	......	*25 0*	*5 0*	*7.0*		Cottonseed meal, linseed meal, wheat flour, oat meal, powdered milk and salt.
			F.†	10.5	22.5	4.6	4.2	....	
	The J. E. Bartlett Co., Jackson, Mich.								
B 6301	Bartlett's Calf Meal	Jackson	*G.*†	......	*21.0*	*3.0*	*4.0*		Cottonseed meal, malt, ground and baked corn, wheat and barley, blood meal, flaxseed products, salt and sugar.
			F.†	7.0	21.9	3.0	3.6	$5 00	
	Ralston Purina Co., St. Louis, Mo.								
B 6268	Purina Calf Chow Feed	Cadillac	*G.*†	......	*27 0*	*3.2*	*4.5*		Linseed meal, hominy feed, corn feed meal, wheat flour, blood flour and salt.
			F.†	11.2	28.3	3.0	3.1	5 00	
	Ryde & Company, Chicago, Ill.								
B 6273	Ryde's Cream Calf Meal	Big Rapids	*G.*†	......	*25.0*	*5.0*	*6.7*		Cottonseed meal, linseed meal, cocoanut meal, malt flour, hominy feed, wheat flour, ground flaxseed, blood flour, cocoa shell meal, salt, anise, Foenurgreek, locust bean meal, ground beans and lentils.
			F.†	11.3	24 4	4.0	6.2	5 00	
	The Western Feed Mfgrs., Inc., Chicago, Ill.								
B 6240	Gro-Big Calf Meal (with dried buttermilk)	Zeeland	*G.*†	......	*18 0*	*4.0*	*4.0*		Red dog flour, linseed meal, corn flour, oat flour, bone meal, blood meal, alfalfa meal, dried buttermilk, salt, calcium carbonate, dried skim milk, dextrose.
			F.†	11.5	14.0	3.7	2.5	....	
	HOG FEEDS.								
	Amendt Milling Co., Monroe, Mich.								
B 6370	"Ameo Pig" Feed	Monroe	*G.*†	......	*15.0*	*4.5*	*8.0*		Linseed meal, gluten feed, cracked corn, corn feed meal, middlings, barley, ground oats, dried buttermilk, tankage and salt.
			F.†	10.0	22.7	4.0	6.3	48 00	
	Arcady Farms Milling Co., Chicago, Ill.								
B 6167	Arcady Hog Meal & Humus	Ravenna	*G.*†	......	*18.0*	*4.5*	*7.0*		Humus, digester tankage, linseed meal, screenings, hominy feed, corn oilcake meal, corn feed meal, wheat middlings, molasses.
			F.†	11.5	18.9	5.1	7.8	80 00	
	Caughey-Jossman Co., Detroit, Mich.								
B 6328	Common Sense Hog Meal	Detroit	*G.*†	......	*12.0*	*5.5*	*10.0*		Cottonseed meal, linseed meal, corn meal, wheat bran and middlings oat meal mill by-product, buckwheat hulls.
			F.†	11.4	17.6	5.0	8.3	46 00	

	Corn Products Refining Co., New York, N. Y.								
			G.†	......	*18.0*	*7.0*	*13.0*		Corn oil cake meal.
B 6016	Diamond Hog Meal	Saline	F.†	10.2	23.7	8.3	8.0	....	
	The C. E. DePuy Company, Pontiac, Mich.								
			G.†	......	*13.5*	*3.7*	*7.0*		Linseed meal, ground corn, wheat bran and middlings, ground barley and ground oats.
B 6083	Pig Meal	Pontiac	F.†	12.0	13.2	3.8	5.1	50 00	
	Hales & Hunter Co., Chicago, Ill.								
			G.†	......	*16.0*	*4 0*	*9.0*		Corn feed meal, wheat bran, flour middlings, ground oats, digester tankage, alfalfa meal, ground barley and salt.
B 6248	College Hog Feed	Muskegon	F.†	10.9	17.4	4.2	9.0	62 00	
	Chas. A. Krause Milling Co., Milwaukee, Wis.								
			G.†	......	*13.0*	*6 0*	*4.5*		Corn germ meal, hominy feed, corn re dog flour, tankage and salt.
B 6079	Badger Homohog Feed	Pontiac	F.†	10 0	15.9	6 6	4.6	2 50	Same as B 6079.
B 6125	Badger Homohog Feed	Coopersville		10.3	13 3	4.8	3.5	....	
		Average		10 2	14.6	5.7	4 1		
	The McMillen Co., Fort Wayne, Ind.								
			G.†	......	*17.5*	*4 0*	*9 0*		Linseed meal, cocoanut meal, corn germ meal, ground corn, wheat middlings, ground barley, red dog flour, tankage, alfalfa meal, molasses, gluten feed and salt.
B 6153	Wayne Hog Feed with Molasses	Marcellus	F.†	10.7	20.2	3.4	7.6	....	
	Park & Pollard Co., Chicago, Ill.								
			G.†	......	*15 0*	*6.0*	*13.0*		Linseed meal, cocoanut meal, peanut meal, hominy feed, corn germ meal, corn feed meal, wheat middlings, meat, fish, bone meal, alfalfa meal, rice bran, calcium carbonate, oat meal mill by-products, velvet bean meal and salt.
B 6281	"Go-Tu-It" Hog Ration	Muskegon Heights	F.†	10.4	18.7	4.4	10.2	3 00	
	Ralston Purina Co., St. Louis, Mo.								
			G.†	......	*15 0*	*2 5*	*9.0*		Linseed meal, gluten feed, corn meal, hominy feed, digester tankage, alfalfa meal, molasses, charcoal and salt.
B 6234	Purina Pig Chow	Holland	F.†	13 2	15.9	3.6	5.1	66 00	
	DAIRY AND STOCK FEEDS								
	Amendt Milling Co., Monroe, Mich.								
			G.†	......	*22 0*	*5 0*	*13 0*		Cottonseed meal, linseed meal, brewers' grains, gluten feed, corn feed meal, wheat bran and middlings, vinegar grains.
B 6239	"Amco" Dairy Feed	Monroe	F.†	8 9	24.8	5.5	10.0	48 00	
	J. J. Badenoch Company, Chicago, Ill.								
			G.†	......	*26.0*	*5.0*	*14 0*		Cottonseed meal, linseed meal, peanut meal, gluten feed, hominy feed, corn feed meal, wheat bran and middlings, oats, barley and salt.
B 6194	Graingold Dairy Ration	Petoskey	F.†	10 5	26.0	5.6	8.8	....	
			G.†	......	*26.0*	*5.0*	*12 0*		Cottonseed meal, linseed meal, peanut meal, gluten feed, corn feed meal, wheat bran and midds, barley, clipped oat by-product, calcium phosphate and salt.
B 6193	Milky Way Dairy Ration	Petoskey	F.†	10.4	23.3	4.7	11.3	60 00	
B 6229	Milky Way Dairy Ration	Holland		11.0	21.1	4.5	7 9	65 00	Same as B 6193; without calcium phosphate and corn feed meal.
		Average		10.7	22.2	4.6	9 6		

†Abbreviation for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	DAIRY AND STOCK FEEDS.—Continued.								
	Chas. F. Bartlett Co., Grand Rapids, Mich.								
			G.†	......	*25.0*	*5.5*	*14.0*		
B 6144	Economy Ready Ration Dairy Feed	Augusta	F.†	7.9	26.8	5.9	12.2	....	Cottonseed meal, linseed meal, brewers' grains, gluten feed, ground wheat, wheat bran and middlings and rice bran.
B 6199	Economy Ready Ration Dairy Feed	Augusta		8.5	28.0	6.0	11.1	....	Same as B 6144, without wheat middlings and ground wheat; with CXX feed.
B 6200	Economy Ready Ration Dairy Feed	Augusta		8.9	25.3	6.7	11.2	....	Same as B 6199.
		Average		8.4	26.7	6.2	11.5		
	Caughey-Jossman Co., Detroit, Mich.								
			G.†	......	*20.0*	*5.0*	*11.0*		
B 6325	Common Sense Dairy Feed	Detroit	F.†	10.4	**18.2**	5.0	12.0	$46 00	Cottonseed meal, linseed meal, gluten feed, corn meal, ground kaffir corn, wheat bran and middlings, alfalfa meal, oat meal mill by-product, buckwheat hulls.
	Chapin & Company, Chicago, Ill.								
			G.†	......	*20.0*	*3.0*	*10.0*		
B 6123	Acorn Dairy Feed	Coopersville	F.†	9.7	**18.9**	3.1	6.8	....	Cottonseed meal, linseed meal, corn gluten feed, corn feed meal kaffir corn, wheat bran, cocoanut meal, ivory nut meal and salt.
	The C. E. DePuy Co., Pontiac, Mich.								
			G.†	......	*17.3*	*4.0*	*9.2*		
B 6085	The C. E. DePuy Co.'s Dairy Feed	Pontiac	F.†	10.9	20.0	4.9	6.5	50 00	Cottonseed meal, linseed meal, corn cob meal, barley, oats, oat meal mill by-product, salt.
	Harris Milling Co., Mt. Pleasant, Mich.								
			G.†	......	*12.0*	*3.5*	*7.0*		
B 6269	Hi-Value Stock Feed	Cadillac	F.†	11.4	11.5	3.8	5.5	46 00	Linseed meal, corn, kaffir corn, milo, barley, oats, wheat bran and middlings, corn feed meal.
	Chas. A. Krause Milling Co., Milwaukee, Wis.								
			G.†	......	*20.0*	*4.5*	*15.0*		
B 6161	Badger Cream City Dairy Feed	Niles	F.†	11.9	21.3	4.2	10.4	....	Cottonseed meal, linseed meal, brewers' grains, malt sprouts, corn germ meal, gluten feed, hominy feed, wheat bran and middlings, oat meal mill by-products, copra meal, salt.
B 6254	Badger Cream City Dairy Feed	Hudsonville		11.0	20.0	5.0	11.6	55 00	Same as B 6161, without copra meal; with corn feed meal.
		Average		11.5	20.7	4.6	11.0		
			G.†	......	*9.0*	*3.5*	*8.0*		
B 6278	Badger Monopoly Feed	Grand Haven	F.†	12.2	10.1	3.2	4.9	2 25	Corn, kaffir corn, barley, oats.
			G.†	......	*24.0*	*5.0*	*10.0*		
B 6187	Krause Dairy Feed	Petoskey	F.†	11.3	24.0	5.9	10.1	70 00	Cottonseed meal, linseed meal, brewers' grains, malt sprouts, gluten feed, hominy feed, corn germ meal, wheat bran and middlings copra meal, salt.
B 6257	Krause Dairy Feed	Holland		10.9	23.9	5.5	8.4	60 00	Same as B 6187, with corn feed meal.
		Average		11.1	23.9	5.7	9.3		

	The Larrowe Milling Co., Detroit, Mich.								
			G.†	......	*20.0*	*3.5*	*14.0*		
B 6068	Larro-Feed	Mason	F.†	9.4	21.1	3.8	10.8	60 00	Cottonseed meal, linseed meal, gluten feed, wheat bran and middlings, dried beet pulp and salt.
B 6246	Larro-Feed	Comstock Park		10.2	22.1	4.5	11.1	55 00	Same as B 6068.
		Average		9.8	21.6	4.2	11.0		
	Lichtenberg & Son, Detroit, Mich.								
			G.†	......	*20.0*	*3.5*	*9.0*		
B 6343	Lichtenberg's Chop Feed	Detroit	F.†	11.7	8.9	3.7	5.9	27 00	Corn meal, oat hulls, oat clippings.
	Nowak Milling Co., Buffalo, N. Y.								
			G.†	......	*20.0*	*4.0*	*15.0*		
B 6132	Domino Creamery Feed	Hamilton	F.†	9.9	21.3	5.4	12.3	....	Cottonseed meal, linseed meal, gluten feed, wheat bran, cocoanut oil meal, salt, ground and bolted grain screenings, brewers' grains.
B 6125	Domino Creamery Feed	Zeeland		8.8	21.1	5.5	12.5	60 00	Same as B 6132, without gluten feed.
B 6228	Domino Creamery Feed	Holland		10.5	**18.0**	5.3	11.5	60 00	Same as B 6132, with cocoanut oil meal.
B 6295	Domino Creamery Feed	Muskegon		10.2	**18.9**	4.0	10.1	....	Same as B 6132.
		Average		9.9	19.8	5.1	11.6		
			G.†	......	*24.5*	*4.5*	*15.0*		
B 6133	Domino 24½ Dry Dairy Ration	Hamilton	F.†	10.1	28.7	6.3	11.0	....	Cottonseed meal, linseed meal, gluten feed, corn feed meal, wheat bran, alfalfa meal, cocoanut oil meal.
B 6296	Domino 24½ Dry Dairy Ration	Muskegon		10.1	26.6	6.0	11.9	....	Same as B 6133.
		Average		10.1	27.7	6.2	11.5		
	Norton-Smith Feed Co., Detroit, Mich.								
			G.†	......	*20.0*	*4.0*	*10.0*		
B 5951	Milkmor Dairy Feed	Romeo	F.†	9.4	20.4	5.3	**11.8**	65 00	Cottonseed meal, linseed meal, gluten feed, corn, wheat bran and middlings, barley, oat feed, screenings, cocoa shell meal and salt.
	Park & Pollard Co., Chicago, Ill.								
			G.†	......	*24.0*	*5.0*	*14.0*		
B 5929	Stevens "44" Dairy Ration	Fowlerville	F.†	9.6	24.3	7.1	10.1	74 50	Cottonseed meal, linseed meal, cocoanut oil meal, brewers' grains, corn distillers' grains, gluten feed, hominy meal, corn meal, wheat meal and middlings, buckwheat, grits, pea bran and salt.
B 5939	Stevens "44" Dairy Ration	Mason		8.9	24.5	7.0	10.8	3 00	Same as B 5929, without wheat meal and pea bran; with wheat bran and pea meal.
B 6134	Stevens "44" Dairy Ration	Hamilton		9.1	25.2	6.4	11.4	....	Same as B 5929, without wheatmeal and buckwheat grits; with wheat bran, pea meal, barley and buckwheat bran.
B 6227	Stevens "44" Dairy Ration	Holland		9.8	24.8	6.9	10.8	66 00	Same as B 5929, without wheat meal and pea bran; with wheat bran, pea meal and barley.
		Average		9.4	24.7	6.9	10.8		
	Pillsbury Flour Mills Co. Minneapolis Minn.								
			G.†	......	*19.0*	*4.0*	*11.0*		
B 6115	Pillsbury's Dairy Ration	Wayland	F.†	9.5	19.4	5.1	10.0	60 00	Cottonseed meal, linseed meal, gluten feed, hominy feed, wheat bran and middlings, oats and salt.

†Abbreviation for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	DAIRY AND STOCK FEEDS.—Continued.								
	Quaker Oats Co., Chicago, Ill.								
			G.†	......	*10.0*	*3.2*	*12.0*		
B 6111	Schumacher Feed	Grand Rapids	F.†	8.7	11.4	3.4	11.0	$55 00	Cottonseed meal, linseed meal, hominy feed, corn, wheat bran and middlings, barley, oat meal mill by-product, puffed rice, yellow hominy feed, calcium phosphate and salt.
B 6267	Schumacher Feed	Cadillac		10.1	11.4	3.0	10.3	40 00	Same as B 6111, without calcium phosphate; with puffed wheat.
		Average		9.4	11.4	3.2	10.7		
	Saginaw Milling Co., Saginaw, Mich.								
			G.†	......	*10.5*	*2.0*	*5.0*		
B 5913	Pioneer Stock Feed	Saginaw	F.†	11.3	12.0	3.6	5.7	56 00	Corn meal, bran, barley and oats.
	Scheuren-Mok Mill Co., Detroit, Mich.								
			G.†	......	*9.0*	*3.0*	*7.0*		
B 6311	Eagle Chop Feed	Detroit	F.†	12.9	**7.9**	2.4	5.3	3 00	Corn meal, corn bran, barley hulls, oat hulls, ground screenings.
	Smith Milling Company, Milwaukee, Wis. (Successors to Smith, Perry & Co.)								
			G.†	......	*24.0*	*6.0*	*11.0*		
B 6284	Vitex Dairy Feed	Grand Rapids	F.†	9.7	26.8	6.2	9.9	58 00	Cottonseed meal, linseed meal, brewers' grains, distillers' grains, malt sprouts, gluten feed, hominy feed, corn oil meal, wheat bran and salt.
	David Stott Flour Mills Co., Detroit, Mich.								
			G.†	......	*8.5*	*3.5*	*10.0*		
B 6352	Stott's Winner Feed	Detroit	F.†	11.0	9.1	4.0	7.0	....	Ground corn, corn feed meal, oats, oat meal mill by-products, salt
	The Ubiko Milling Co., Cincinnati, Ohio								
			G.†	......	*24.0*	*5.0*	*10.0*		
B 5928	Union Grains, Ubiko, Biles Ready Dairy Ration	Fowlerville	F.†	9.8	25.0	6.8	8.5	77 40	Cottonseed meal, linseed, meal, cocoanut oil meal, brewers' grains, corn distillers' grains, gluten feed, hominy meal, wheat bran and middlings, salt.
B 6095	Union Grain, Ubiko, Biles Ready Dairy Ration	Ann Arbor		10.0	24.3	6.5	8.7	54 00	Same as B 5928.
		Average		9.9	24.7	6.7	8.6		
	Western Feed Mfgrs., Inc., Chicago, Ill.								
			G.†	......	*24.0*	*5.0*	*10.0*		
B 5924	Big Flo Dairy Feed	Lansing	F.†	9.8	**22.1**	7.1	**11.2**	3 90	Cottonseed meal, linseed meal, gluten feed, wheat bran and middlings, rice bran, rice polish and salt.
B 6290	Big Flo Dairy Feed	Niles		10.0	**22.6**	5.8	10.9	....	Same as B 5924, without rice polish and salt; with ground barley and alfalfa meal.
		Average		9.9	**22.4**	6.5	11.0		

	Western Grain Products Co. Hammond, Ind.								
			G.†	......	*20.0*	*4.0*	*13.5*		Cottonseed meal, linseed meal, brewers' grains, gluten feed, corn, wheat bran; recleaned wheat screenings, clipped oat by-product.
B 6131	Calumet Dairy Feed	Grand Rapids	F.†	9.4	20.8	5.5	12.6	....	
	A. K. Zinn & Company, Battle Creek, Mich.								
			G.†	......	*22.0*	*4.5*	*9.5*		Cottonseed meal, linseed meal, gluten feed, brewers' grains, malt feed, corn feed meal, wheat bran and middlings, oats, cooked corn grits and salt.
B 6504	Peerless Dairy Ration	Battle Creek	F.†	9.6	24.1	5.4	8.0	45 00	
	MOLASSES DAIRY AND STOCK FEEDS								
	American Milling Co., Peoria, Ill.								
			G.†	......	*25.0*	*5.0*	*8.0*		Cottonseed meal, linseed meal, cocoanut meal, peanut meal, distillers' grains, gluten feed, wheat bran, alfalfa meal, molasses, calcium carbonate and salt.
B 6165	Amco Dairy Feed	Conklin	F.†	12.0	24.8	5.4	10.8	....	
B 6172	Amco Dairy Feed	Sparta		10.3	27.4	5.7	9.0	68 00	Same as B 6165.
B 6378	Amco Dairy Feed	Morenci		10.4	28.4	4.4	7.6	....	Same as B 6165, without calcium carbonate.
		Average		10.9	26.9	5.2	9.1		
			G.†	......	*20.0*	*4.5*	*8.0*		Cottonseed meal, linseed meal, cocoanut oil meal, peanut meal, distillers' grains, gluten feed, corn feed meal, wheat bran, alfalfa meal, molasses, salt and calcium carbonate.
B 6137	Empire 20% Dairy Feed	Hamilton	F.†	10.3	23.3	4.7	8.3	....	
B 6279	Empire 20% Dairy Feed	Grand Haven		11.4	24.9	4.1	6.6	54 00	Same as B 6137, without calcium carbonate.
B 6379	Empire 20% Dairy Feed	Morenci		9.8	24.1	4.7	7.1	....	Same as B 6279.
		Average		10.5	24.1	4.5	7.3		
			G.†	......	*16.5*	*3.5*	*10.0*		Cottonseed meal, linseed meal, cocoanut oil meal, distillers' grains, corn feed meal, salt, clipped oat by-products, ground screenings, wheat bran, calcium carbonate.
B 6173	Sucrene Dairy Feed	Sparta	F.†	11.2	16.6	4.6	11.6	52 00	
	Arcady Farms Milling Co., Chicago, Ill.								
			G.†	......	*16.5*	*3.5*	*13.5*		Cottonseed meal, linseed meal, gluten feed, wheat bran, cleaned, ground and bolted wheat screenings, ground and bolted clipped oat by-product molasses and salt.
B 6166	Arcady Dairy Feed	Ravenna	F.†	11.6	16.3	5.4	12.4	65 00	
			G.†	......	*20.0*	*4.0*	*12.0*		Cottonseed meal, linseed meal, gluten feed, wheat bran and middlings, screenings, molasses, clipped oat by-product, salt, oatmeal mill by-product, corn oil cake meal.
B 6093	Arco Milk Ration	Ann Arbor	F.†	10.8	20.2	4.7	11.3	52 00	
B 6169	Arco Milk Ration	Grand Rapids		11.1	21.1	5.4	10.2	54 00	Same as B 6093, with corn feed meal.
B 6291	Arco Milk Ration	Belmont		12.0	20.8	5.4	11.2	51 00	Same as B 6093, without oat meal mill by-product.
		Average		11.3	20.7	5.2	10.9		
			G.†	......	*25.0*	*5.0*	*11.0*		Cottonseed meal, linseed meal, brewers' grains, cocoanut oil meal, distillers' grains, gluten feed, hominy feed, wheat bran and middlings, molasses and salt.
B 6170	Certified Dairy Feed	Grand Rapids	F.†	11.4	24.5	5.4	9.8	64 00	

†Abbreviation for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	MOLASSES DAIRY AND STOCK FEEDS—Cont.								
	Arcady Farms Milling Co.—Continued.								
			G.†	.....	*21.0*	*4.0*	*10.0*		Cottonseed meal, linseed meal, gluten feed, corn feed meal, wheat bran, dried beet pulp, molasses and salt.
B 6396	Producers Ready Ration with Beet Pulp	Ypsilanti	F.†	11.6	24.8	4.0	7.3	....	
			G.†	.....	*24.0*	*5.0*	*10.0*		Cottonseed meal, linseed meal, dried grains (barley, malt and corn), corn germ meal, gluten feed, wheat bran and middlings, molasses and salt.
B 5974	Red D Dairy Feed	Milford	F.†	11.2	23.8	5.3	7.9	....	
B 6092	Red D Dairy Feed	Ann Arbor		10.4	25.5	5.9	9.4	$2 70	Same as B 5974.
B 6292	Red D Dairy Feed	Belmont		12.5	24.8	5.9	8.1	54 00	Same as B 5974, with brewer's grains and dried beet pulp.
		Average		11.4	24.7	5.7	8.5		
	Grain Belt Mills Co., So. St. Joseph, Mo.								
			G.†	.....	*20.0*	*3.0*	*12.0*		Cottonseed meal, corn germ meal, wheat bran, alfalfa, molasses, corn feed meal, salt.
B 6120	Gee Bee Dairy Feed	Allegan	F.†	11.2	20.7	3.7	10.8	....	
			G.†	.....	*16.0*	*4.0*	*15.0*		Cottonseed meal, corn feed meal, alfalfa meal, molasses, wheat screenings and salt.
B 6119	Grain Belt Red D Dairy Feed	Allegan	F.†	12.6	18.3	4.8	12.0	....	
	Chas. A. Krause Milling Co., Milwaukee, Wis.								
			G.†	.....	*16.5*	*3.5*	*18.0*		Cottonseed meal, ground screenings, alfalfa meal, flax plant by-product, molasses and salt.
B 6077	Badger Dairy Feed	Pontiac	F.†	10.0	15.4	3.4	24.5	2 65	
B 6114	Badger Dairy Feed	Grand Rapids		8.2	18.0	5.6	20.5	53 00	Same as B 6077.
B 6124	Badger Dairy Feed	Coopersville		9.4	17.6	6.4	19.0	....	Same as B 6077.
B 6162	Badger Dairy Feed	Niles		10.0	20.2	4.3	18.9	....	Same as B 6077.
		Average		9.4	17.8	4.9	20.7		
	Ladish Milling Co., Milwaukee, Wis.								
			G.†	.....	*24.0*	*4.5*	*12.0*		Cottonseed meal, linseed meal, gluten feed, hominy feed, wheat bran, ground oats, alfalfa meal, molasses, copra meal and salt.
B 6276	Record Maker Dairy Feed	Maine	F.†	12.0	25.6	5.5	7.6	....	
	Lichtenberg & Son, Detroit, Mich.								
			G.†	.....	*23.0*	*4.0*	*12.0*		Cottonseed meal, brewers' grains, distillers' grains, corn feed meal, wheat bran and middlings, gluten feed, oat hulls, molasses and salt.
B 6344	Faramel Dairy Feed	Detroit	F.†	8.6	21.7	5.2	10.7	43 00	
	Ralston Purina Co., St. Louis, Mo.								
			G.†	.....	*24.0*	*4.3*	*12.0*		Cottonseed meal, linseed meal, gluten feed, hominy feed, alfalfa, molasses and salt.
B 6042	Purina Cow Chow Feed	Port Huron	F.†	9.7	27.8	4.4	10.4	3 25	
B 6206	Purina Cow Chow Feed	Greenville		10.5	26.1	4.2	11.3	60 00	Same as B 6042 with corn feed meal.
B 6230	Purina Cow Chow Feed	Holland		11.0	26.6	4.1	8.8	66 00	Same as B 6042.
		Average		10.4	26.8	4.2	10.2		

	Western Feed Mfgrs., Inc., Chicago, Ill.								
			G.†	.....	*16.0*	*3.0*	*10.0*		Cottonseed meal, gluten feed, corn feed meal, wheat bran and middlings, molasses, oat hulls, rice bran and salt.
B 5919	"Rep" Dairy Feed	Lansing	F.†	10.8	15.1	3.9	8.8	3 75	
	Western Grain Products Co., Hammond, Ind.								
			G.†	.....	*16.5*	*4.0*	*13.5*		Cottonseed meal, brewers' grains, gluten feed, ground screenings molasses, ground clipped oat by-product, salt.
B 6130	Hammond Dairy Feed	Grand Rapids	F.†	9.7	16.6	6.4	12.3	....	
	HORSE FEEDS.								
	Caughey-Jossman Co., Detroit, Mich.								
			G.†	.....	*8.5*	*4.7*	*7.6*		Corn meal, corn bran, oat hulls.
B 6329	Royal Horse Chop	Detroit	F.†	12.4	10.5	1.3	5.2	30 00	
	Rosenbaum Bros., Chicago, Ill.								
			G.†	.....	*10.0*	*3.0*	*6.0*		Crushed barley, crushed oats, sifted cracked corn.
B 6157	Horse Sense Grain Feed	Niles	F.†	10.8	10.3	3.9	6.0	....	
	MOLASSES HORSE FEEDS.								
	Grain Belt Milling Co., So. St. Joseph, Mo.								
			G.†	.....	*10.0*	*1.5*	*15.0*		Cracked corn, crushed oats, alfalfa meal, molasses and salt.
B 6338	Bronco Horse and Mule Feed	Detroit	F.†	15.3	9.8	2.4	10.2	40 00	
	Hales & Hunter Co., Chicago, Ill.								
			G.†	.....	*10.0*	*2.5*	*10.0*		Cracked corn, wheat bran, crushed barley, crushed oats, molasses.
B 6388	College Horse Feed	Jackson	F.†	12.1	10.3	3.3	3.3	....	
	Chas. A. Krause Milling Co., Milwaukee, Wis.								
			G.†	.....	*9.0*	*1.0*	*16.0*		Cracked corn, oats, oat shorts, oat hulls, alfalfa meal, flax plant by-product, molasses and salt.
B 6323	Badger Pulmor Horse Feed	Detroit	F.†	14.0	8.7	2.1	14.7	38 00	
B 6348	Badger Pulmor Horse Feed	Detroit		16.0	7.6	1.2	17.0	2 30	Cracked corn, crushed oats, oat meal mill by-product, alfalfa meal, molasses, flax plant by-product, salt.
		Average		15.0	8.2	1.7	15.7		
			G.†	.....	*10.0*	*2.5*	*10.0*		Cracked corn, crushed oats, alfalfa, molasses and salt.
B 6321	Krause Horse Feed	Detroit	F.†	14.8	9.2	2.3	9.2	42 00	
	Lichtenberg & Son, Detroit, Mich.								
			G.†	.....	*10.0*	*3.0*	*10.0*		Cracked corn, crushed oats, molasses and salt.
B 6342	Faramel Horse Feed	Detroit	F.†	11.0	10.6	5.0	9.1	40 00	
	The McMillen Co., Fort Wayne, Ind.								
			G.†	.....	*9.0*	*2.0*	*16.0*		Cracked corn, crushed oats, alfalfa meal, molasses.
B 6110	Wayne Horse Feed	Decatur	F.†	12.8	11.5	2.9	12.3	....	
	Nowak Milling Co., Buffalo, N. Y.								
			G.†	.....	*9.0*	*2.0*	*14.0*		Cracked corn, crushed oats, alfalfa, molasses, oats and salt.
B 6260	Domino Horse Feed with Alfalfa	Holland	F.†	15.1	10.6	2.8	14.4	....	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	MOLASSES HORSE FEEDS.—Continued.								
	Omaha Alfalfa Mfg. Co., Omaha, Neb.								
B 6337	Peerless Horse & Mule Feed	Detroit	G.† F.†	..... 15.6	*10.0* 10.5	*1.5* 2.1	*18.0* 12.3	$44 00	Cracked corn, crushed oats, alfalfa meal, molasses.
	M. C. Peters Milling Co., Omaha, Neb.								
B 6315	King Corn Horse and Mule Feed	Detroit	G.† F.†	..... 14.1	*10.0* 10.8	*1.2* 2.0	*18.0* 14.5	43 00	Cracked corn, alfalfa meal, oats and molasses.
B 6314	Rabbit, Horse and Mule Feed	Detroit	G.† F.†	..... 14.3	*10.0* 11.7	*1.5* 2.4	*18.0* 15.7	40 00	Cracked corn, oats, alfalfa meal and molasses.
	Triangle Milling Co., Kansas City, Mo.								
B 6327	Bingo Horse and Mule Feed	Detroit	G.† F.†	..... 16.3	*9.0* 10.2	*2.5* 2.9	*13.0* 8.2		Cracked corn, crushed oats, alfalfa, molasses and salt.
B 6326	Triple Grain Horse and Mule Feed	Detroit	G.† F.†	..... 15.9	*9.0* 9.4	*2.5* 3.0	*12.0* 9.1	....	Cracked corn, alfalfa meal, molasses and salt.
	POULTRY FEEDS.								
	Amendt Milling Co., Monroe, Mich.								
B 6372	"Amco" Baby Chick Feed	Monroe	G.† F.†	..... 11.4	*10.0* 10.8	*2.5* 3.3	*5.0* 2.0	51 00	Finely cracked corn, kaffir corn, milo, ground oat groats, millet and grit.
B 6368	"Amco" Poultry Mash	Monroe	G.† F.†	..... 10.2	*17.0* 24.3	*3.0* 4.8	*10.0* 5.9	55 00	Linseed meal, gluten feed, corn feed meal, wheat bran and middlings, ground oats, meat scraps, dried buttermilk.
B 6316	"Amco" Scratch Grains, without grit and shells	Detroit	G.† F.†	..... 12.3	*10.0* 10.4	*2.5* 3.1	*5.0* 2.2	45 00	Linseed meal, cracked corn, kaffir corn, wheat, rye, barley, buckwheat, oats, screenings, sunflower.
B 6367	"Amco" Scratch Grains, without grit and shells	Monroe		12.7	11.1	2.5	2.6	42 00	Same as B 6316, without sunflower; with milo.
		Average		12.5	10.8	2.8	2.4		
	American Milling Co., Peoria, Ill.								
B 6341	Cluck-Cluck Scratch Feed	Detroit	G.† F.†	..... 11.9	*10.0* 10.4	*2.5* 2.2	*5.0* 1.9	46 00	Cracked corn, kaffir corn, wheat, barley, buckwheat, oats, sunflower.
B 6099	Tip Top Scratch Feed	Jackson	G.† F.†	..... 13.8	*10.0* 9.9	*2.5* 2.8	*5.0* 1.4	....	Cracked corn, kaffir corn, wheat, barley, oats, sunflower.

	Arcady Farms Milling Co., Chicago, Ill.								
B 6395	Arcady Buttermilk Egg Mash	Ypsilanti	G.†	.....	*20.0*	*4.5*	*9.0*		Cottonseed meal, linseed meal, gluten feed, corn feed meal, wheat bran and middlings, oat meal, oat shorts, meat scraps, bone meal, alfalfa meal, dried buttermilk, salt.
			F.†	10.5	20.6	4.3	8.8	....	
B 5999	Arcady Poultry Feed	Adrian	G.†	.....	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats and sunflower.
			F.†	11.9	10.4	3.2	2.8	3.10	
	H. W. Baer, Pontiac, Mich.								
B 6081	Baer's Chicken Feed	Pontiac	G.†	.....	*9.7*	*3.4*	*2.8*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats and sunflower.
			F.†	13.7	10.6	2.4	2.1	3.40	
	J. J. Badenoch Co., Chicago. Ill.								
B 6195	Sunflower Poultry Feed	Petoskey	G.†	.....	*9.5*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats, milo and sunflower.
			F.†	13.1	9.6	3.2	2.1	3.00	
	Bay City Grain Co., Bay City, Mich.								
B 6029	Chicken Feed	Bay City	G.†	.....	*10.2*	*2.6*	*3.2*		Cracked corn, wheat, barley, buckwheat and oats.
			F.†	14.6	10.2	2.6	3.2	2.40	
	Bromfield & Colvin Co., Bay City, Mich.								
B 6027	Egg Producer	Bay City	G.†	.....	*16.7*	*3.4*	*7.5*		Cottonseed meal, linseed meal, corn, kaffir corn, wheat, wheat bran and middlings, rye, barley, oats, beans, alfalfa meal, buckwheat hulls, CXX feed, salt.
			F.†	10.0	16.7	3.4	7.5	3.50	
B 6023	Pure Grain Chicken Feed	Bay City	G.†	.....	*10.6*	*3.1*	*3.0*		Chess, kaffir corn, cracked corn, wheat, rye, oats, barley, buckwheat and sunflower.
			F.†	12.8	10.6	3.1	3.0	2.10	
	Cass Bean & Grain Co., Salzburg, Mich.								
B 6020	Chick Feed	Salzburg	G.†	.....	*9.5*	*2.5*	*5.0*		Corn, cracked corn, wheat, barley, buckwheat, oats, screenings.
			F.†	12.3	11.0	2.7	3.8	2.50	
	Caughey-Jossman Co., Detroit, Mich.								
B 6332	CCC Scratch Feed	Detroit	G.†	.....	*9.8*	*3.6*	*3.2*		Cracked corn, wheat, barley, buckwheat, oats, chess, grit.
			F.†	12.7	10.1	2.4	2.6	41.00	
B 6330	Common Sense Baby Chick Feed	Detroit	G.†	.....	*10.0*	*2.5*	*5.0*		Finely cracked corn, cracked kaffir corn, cracked milo, wheat, millet and wild seeds.
			F.†	12.5	10.3	3.1	3.3	....	
B 6331	Common sense Developing Feed	Detroit	G.†	.....	*9.0*	*2.5*	*2.5*		Cracked corn, kaffir corn, milo maize, wheat, buckwheat, oats, chess and millet.
			F.†	13.2	9.8	2.6	2.0	46.00	
B 6324	Common sense Egg Mash	Detroit	G.†	.....	*20.0*	*5.0*	*8.0*		Linseed meal, corn meal, kaffir corn, screenings, grit, beef scraps, alfalfa meal, oat meal mill by-products, wheat bran and middlings, buckwheat hulls.
			F.†	10.0	16.5	4.0	7.6	46.00	
B 6334	Common Sense Scratch Feed	Detroit	G.†	.....	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, buckwheat, barley, oats, sunflower milo maize.
			F.†	13.4	10.4	2.8	3.0	44.00	
	Chatfield Milling & Grain Co., Bay City, Mich.								
B 6031	Plymouth Rock Poultry Feed	Bay City	G.†	.....	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, rye, cracked kaffir corn, wheat, barley, buckwheat, oats, shell, chess.
			F.†	12.6	10.1	3.1	2.9	....	

†Abbreviation for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	POULTRY FEEDS.—Continued.								
	Commercial Milling Co., Detroit, Mich.								
			G.†	......	*9.0*	*2.4*	*4.0*		
B 6359	Henkel's Poultry Feed	Detroit	F.†	11.9	9.8	2.8	2.0	....	Cracked corn, kaffir corn, wheat, buckwheat, screenings, sunflower and grit.
			G.†	......	*9.0*	*2.4*	*4.0*	....	
B 6360	No. 1 Poultry Feed Special	Detroit	F.†	12.0	10.7	3.5	3.0	....	Cracked corn, milo, wheat, rye, buckwheat, oats, screenings and sunflower.
	The C. E. DePuy Co., Pontiac, Mich.								
			G.†	......	*10.0*	*2.5*	*5.0*		
B 6087	Peerless Scratch Feed	Pontiac	F.†	12.1	10.5	3.2	2.1	$3.50	Corn, cracked corn, kaffir corn, wheat, rye, barley, buckwheat and oats.
	The Albert Dickinson Co., Chicago, Ill.								
			G.†	......	*10.0*	*2.5*	*5.0*		
B 6346	Globe Chick Feed, with grit	Detroit	F.†	12.2	10.4	2.5	2.2	2.95	Finely cracked corn, cracked kaffir corn, cracked wheat, oat groats, millet and grit.
B 6398	Globe Chick Feed, with grit	Ypsilanti		11.7	10.4	2.7	2.2	....	Same as B 6346.
		Average		12.0	10.4	2.6	2.2		
			G.†	......	*10.0*	*2.5*	*5.0*		
B 6345	Globe Developing Feed, with grit	Detroit	F.†	10.7	10.1	2.7	2.3	2.85	Cracked corn, kaffir corn, wheat, buckwheat, oats, grit, millet.
			G.†	......	*20.0*	*5.0*	*10.0*		
B 6065	Globe Egg Mash	Mt. Clemens	F.†	10.5	19.6	4.9	7.2	3.25	Linseed meal, corn feed meal, wheat bran and middlings, meat scraps, alfalfa meal and salt.
B 6298	Globe Egg Mash	Muskegon		10.7	20.9	5.2	8.1	....	Same as B 6065, with gluten feed.
B 6318	Globe Egg Mash	Detroit		10.5	20.8	4.9	8.4	3.50	Same as B 6065.
		Average		10.6	20.4	5.0	7.9		
			G.†	......	*10.0*	*2.5*	*5.0*		
B 6322	Globe Pigeon Feed, no grit	Detroit	F.†	12.3	14.2	3.1	4.1	4.00	Kaffir corn, wheat, buckwheat, peas, millet and hemp.
			G.†	......	*10.0*	*2.5*	*5.0*		
B 6064	Globe Scratch Feed, no grit	Mt. Clemens	F.†	12.3	11.1	2.9	2.6	3.25	Linseed cake, cracked corn, kaffir corn, barley, wheat, buckwheat, oats and sunflower.
B 6075	Globe Scratch Feed, no grit	Birmingham		12.4	10.4	2.9	2.1	3.50	Same as B 6064, with rye and weed seeds.
B 6297	Globe Scratch Feed, no grit	Muskegon		13.1	10.6	3.3	2.6	....	Same as B 6064.
		Average		12.6	10.7	3.0	2.4		

			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, buckwheat, peas, millet and hemp.
B 6320	King Pigeon Feed, no grit	Detroit	F.†	12.4	10.9	3.2	2.2	3 70	
			G.†	......	*9.5*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, oats.
B 6349	Rival Scratch Feed, no grit	Detroit	F.†	13.7	10.0	2.8	2.0	2 60	
	J. F. Eesley Milling Co., Plainwell, Mich.								
			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, oats, buckwheat.
B 6523	Pure Gold Scratch Feed	Plainwell	F.†	12.5	10.4	2.8	2.8	46 00	
	Grand Rapids Grain & Mfg. Co., Grand Rapids, Mich.								
			G.†	......	*16.0*	*3.0*	*10.0*		Linseed meal, corn feed meal, wheat bran and middlings, meat scraps, fish scraps, alfalfa meal and grit.
B 6262	Purity Egg Mash	Grand Rapids	F.†	12.9	15.9	3.7	6.6	55 00	
B 6293	Purity Egg Mash	Hudsonville		10.4	14.9	4.4	5.7	3 25	Same as B 6262.
B 6294	Purity Egg Mash	Hudsonville		10.5	15.5	4.4	6.4	3 25	Same as B 6262.
		Average		11.3	15.4	4.2	6.2		
			G.†	......	*9.0*	*3.5*	*10.0*		Cracked corn sifted, kaffir corn, wheat, barley, oats, buckwheat and sunflower.
B 6263	Purity Scratch Feed, no grit	Grand Rapids	F.†	15.3	9.6	3.6	1.5	50 00	
			G.†	......	*9.0*	*3.5*	*10.0*		Same as B 6263, with grit.
B 6264	Purity Scratch Feed, with grit	Grand Rapids	F.†	13.3	9.1	2.8	1.8	47 50	
	Grain Belt Mills Co., So. St. Joseph, Mo.								
			G.†	......	*10.0*	*3.0*	*5.0*		Cracked corn, kaffir corn, milo, wheat, barley, buckwheat, oats, sunflower, salvage wheat.
B 6121	Gee Bee Hen Feed	Allegan	F.†	11.2	10.6	2.7	2.7	....	
	The Guntrup-Perry Co., Detroit, Mich.								
			G.†	......	*9.5*	*2.5*	*5.0*		Cracked corn, cracked kaffir corn, wheat, barley, buckwheat, screenings, sunflower and grit.
B 6358	Cadillac Scratch Feed	Detroit	F.†	12.4	9.9	2.5	3.4	2 60	
			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats, sunflower.
B 6357	New Century Scratch Feed, no grit	Detroit	F.†	12.7	10.4	2.6	2.8	2 70	
	Hales & Hunter Co., Chicago, Ill.								
			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats.
B 6306	Morning Glory Scratch Feed, no grit	Detroit	F.†	13.3	9.6	3.5	2.4	2 50	
			G.†	......	*16.0*	*4.5*	*9.0*		Linseed meal, gluten feed, corn feed meal, wheat middlings, oats, meat scraps, alfalfa meal, dried buttermilk, calcium carbonate.
B 6308	Red Comb Egg Mash with dried buttermilk	Detroit	F.†	10.4	17.8	5.8	4.9	3 15	
			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats, sunflower.
B 6110	Red Comb Scratch Feed, no grit	Grand Rapids	F.†	11.6	10.3	2.5	2.6	66 00	
B 6307	Red Comb Scratch Feed, no grit	Detroit		13.0	10.0	3.7	2.1	2 90	Same as B 6110.
		Average		12.3	10.1	3.1	2.4		
	Hankey Milling Co., Petoskey, Mich.								
			G.†	......	*9.5*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats, sunflower and rye.
B 6189	Vim Scratch Feed	Petoskey	F.†	13.4	9.9	3.0	3.0	58 00	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	POULTRY FEEDS.—Continued								
	Holland Co-operative Association, Holland, Mich.								
			G.†	......	*17.0*	*5.5*	*7.0*		Ground corn, wheat bran and middlings, rye, barley, oats, tankage.
B 6233	Co-Operative	Holland	F.†	11.3	17.8	6.1	5.6	$63 00	
	Chas. A. Krause Milling Co., Milwaukee, Wis.								
			G.†	......	*9.0*	*1.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats.
B 6350	Badger Cream City Scratch Feed, no grit	Detroit	F†	13.8	9.4	2.5	1.9	2 60	
			G.†	......	*18.0*	*3.2*	*10.0*		Corn feed meal, gr. screenings, corn germ meal, corn flour, wheat bran and middlings, meat scraps, alfalfa meal, dried buttermilk.
B 6082	Badger Laying Mash	Pontiac	F.†	8.4	18.0	4.5	10.5	3 50	
B 6347	Badger Laying Mash	Detroit		10.6	17.9	5.2	7.6	3 20	Corn germ meal, hominy feed, red dog flour, wheat bran and middlings, meat scraps, fish meal, alfalfa meal, dried buttermilk.
		Average		9.5	17.9	4.9	9.1		
			G.†	......	*9.0*	*1.5*	*5.0*		Cracked corn, kaffir corn, milo maize, wheat, barley, buckwheat, oats and sunflower.
B 6080	Krause Scratch Feed, no grit	Pontiac	F.†	13.3	10.0	2.4	2.0	3 40	
	Ladish Milling Co., Milwaukee, Wis.								
			G.†	......	*9.5*	*2.5*	*5.0*		Cracked corn, cracked kaffir corn, cracked wheat and millet.
B 6270	Record Maker Chick Feed, no grit	Reed City	F.†	12.5	10.5	3.4	1.9	3 00	
			G.†	......	*20.0*	*5.0*	*10.5*		Linseed meal, gluten feed, corn feed meal, wheat bran and middlings, ground oats, meat scraps, alfalfa meal and salt.
B 6285	True Value Laying Mash	Grand Rapids	F.†	11.0	20.7	5.1	7.5	3 25	
			G.†	......	*16.0*	*4.0*	*6.0*		Linseed meal, gluten feed, corn feed meal, wheat bran and middlings, ground oats, meat meal, alfalfa meal.
B 6271	True Value Poultry Mash	Reed City	F.†	10.5	22.3	4.5	9.2	3 25	
	The McMillen Co., Fort Wayne, Ind.								
			G.†	......	*10.0*	*3.0*	*4.6*		Corn, kaffir corn, wheat, barley, buckwheat, oats, sunflower.
B 6001	Wayne Scratch Feed	Hudson	F.†	12.6	9.6	3.2	2.3	2 50	
	McMorran Milling Co., Port Huron, Mich.								
			G.†	......	*8.0*	*2.0*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, sunflower.
B 6405	Crest Poultry Food	Port Huron	F.†	14.7	10.2	3.3	2.2	....	
	Michigan Milling Co., Ann Arbor, Mich.								
			G.†	......	*10.0*	*2.5*	*5.0*		Corn, cracked corn, wheat, rye, barley, buckwheat, oats and screenings.
B 6094	Mimico Scratch Feed	Ann Arbor	F.†	12.3	12.3	2.7	2.4	....	

	Mt. Clemens Milling Co., Mt. Clemens, Mich.								
			G.†	.....	*10.0*	*2.5*	*5.0*		Corn, cracked corn, wheat, barley, buckwheat, oats and screenings.
B 6061	Peerless Poultry Feed	Mt. Clemens	F.†	14.7	10.5	2.7	3.0	2 90	
	Nowak Milling Corporation, Buffalo, N. Y.								
			G.†	.....	*20.0*	*3.0*	*10.0*		Linseed meal, gluten feed, corn feed meal, wheat bran and middlings, oats, meat scraps, bone meal, alfalfa meal and meat flour,
B 6182	Domino Laying Mash	Hudsonville	F.†	10.7	21.9	4.4	9.8	4 00	
	Park & Pollard Co. of Ill., Chicao, Ill.								
			G.†	.....	*18.0*	*1.5*	*12.0*		Corn feed meal, ground wheat bran, wheat middlings, ground barley, meat scraps, fish, bone meal, alfalfa meal, salt, calcium phosphate linestone.
B 6053	"Lay or Bust" Dry Mash	Flint	F.†	9.1	19.6	4.1	8.6	3 50	
	Peninsular Milling Co., Flint, Mich.								
			G.†	.....	*10.0*	*2.5*	*5.0*		Corn cockle, chess, cracked corn, kaffir corn, wheat, barley, oats and buckwheat.
B 6049	Peninsular Scratch Feed	Flint	F.†	12.2	11.1	2.7	2.8	3 00	
			G.†	.....	*10.0*	*2.5*	*5.0*		Same as B 6049, with shells and sunflower.
B 6048	Peninsular Scratch Feed, with shells	Flint	F.†	12.3	10.7	2.2	2.5	2 90	
	Postum Cereal Co., Battle Creek, Mich.								
			G.†	.....	*8.0*	*1.0*	*10.0*		Corn, oats and wheat screenings.
B 6516	Chicken Feed	Battle Creek	F.†	10.9	12.2	3.0	4.0	24 00	
	Prairie State Milling Co., Chicago, Ill.								
			G.†	.....	*9.0*	*2.5*	*2.5*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats, weed seeds and grit.
B 6252	Early Egg Scratch Feed, with grit	Muskegon	F.†	11.5	10.4	3.7	3.1	46 00	
			G.†	.....	*9.0*	*3.7*	*3.5*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats, weed flower.
B 6252	Red Crown Scratch Feed, no grit	Petoskey	F.†	12.7	10.4	2.8	2.8	3 00	
B 6251	Red Crown Scratch Feed, no grit	Muskegon		11.9	10.7	3.1	2.5	50 00	Same as B 6196.
		Average		12.3	10.6	3.0	2.7		
	The Quaker Oats Co., Chicago, Ill.								
			G.†	.....	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, milo, wheat, barley, sunflower.
B 6392	Big Egg Scratch Grains, no grit	Jackson	F.†	12.5	9.6	2.5	2.0	....	
			G.†	.....	*20.0*	*4.0*	*10.0*		Cottonseed meal, corn gluten feed, hominy feed and meal, wheat bran, oatmeal, screenings, meat scraps, fish bone meal, alfalfa meal.
B 6041	Ful-O-Pep Dry Mash	Port Huron	F.†	9.0	21.7	4.8	9.4	4 00	
B 6069	Ful-O-Pep Dry Mash	Mason		9.5	22.2	5.3	6.3	4 00	Same as B 6011, without hominy screenings.
B 6216	Full-O-Pep Dry Mash	Zeeland		9.2	21.9	5.2	9.2	4 50	Same as B 6041, without hominy meal; with yellow hominy feed.
		Average		9.2	21.9	5.1	8.3		
			G.†	.....	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, milo, wheat, barley, sunflower, buckwheat.
B 6340	Full-O-Pep Scratch Grains	Detroit	F.†	13.1	10.3	2.4	1.6	48 00	
			G.†	.....	*10.0*	*2.5*	*5.0*		Same as B 6340.
B 6339	Schumacher Scratch Grains, no grit	Detroit	F.†	12.9	10.7	2.2	2.1	45 00	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	POULTRY FEEDS.—Continued.								
	Ralston Purina Co., St. Louis, Mo.								
			G.†	......	*19.0*	*4.0*	*10.0*		Gluten feed, corn meal, wheat bran and middlings, meat scraps, alfalfa meal, charcoal and salt.
B 6037	Purina Chicken Chowder, with charcoal	Port Huron	F.†	9.9	20.2	4.3	10.2	$4 00	
			G.†	......	*10.0*	*2.5*	*4.0*		Cracked corn, kaffir corn, barley, buckwheat, milo, wheat, sunflower.
B 6036	Purina Hen Chow Scratch Feed	Port Huron	F.†	13.1	10.6	3.0	2.4	3 00	
	Rosenbaum Bros., Chicago, Ill.								
			G.†	......	*9.0*	*2.0*	*7.0*		Cracked corn, kaffir corn, barley, buckwheat, wheat, oats and grit.
B 6067	"77" Scratch Feed, with grit	Mason	F.†	11.5	9.5	2.6	1.5	3 50	
			G.†	......	*18.0*	*4.0*	*10.0*		Linseed meal, corn feed meal, wheat bran and middlings, barley, milk albumen, oats, meat scraps, bone meal, alfalfa meal, calcium carbonate.
B 6282	Vitality Egg Mash with Milk Albumen	Muskegon Heights	F.†	8.5	18.8	4.1	8.0	3 00	
B 6406	Vitality Egg Mash with Milk Albumen	Port Huron		9.8	19.8	4.6	7.5	....	Same as B 6282.
		Average		9.2	19.3	4.4	7.8		
			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, barley, buckwheat, wheat, sunflower, oats.
B 6305	Vitality Scratch Feed, no grit	Detroit	F.†	11.9	9.9	3.5	2.1	3 25	
	Saginaw Milling Co., Saginaw, Mich.								
			G.†	......	*16.5*	*3.5*	*10.0*		Corn meal, wheat bran and middlings, meat scraps and alfalfa meal.
B 5912	Red Hen Mash	Saginaw	F.†	10.5	19.1	5.0	6.4	66 00	
			G.†	......	*9.5*	*2.7*	*3.0*		Cracked corn, kaffir corn, barley, wheat, sunflower, oats.
B 5915	Red Hen Scratch Feed	Saginaw	F.†	11.8	10.9	3.8	3.9	62 00	
			G.†	......	*9.4*	*2.5*	*3.0*		Cracked corn, kaffir corn, barley, wheat, sunflower, oats and screenings.
B 5916	Wolverine Scratch Feed	Saginaw	F.†	12.0	10.4	2.7	2.5	60 00	
	Scheuren-Mok Mill Co., Detroit, Mich.								
			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, milo, barley, buckwheat, oats, broom corn and grit.
B 6310	Co-operative Scratch No. 2 Feed, with grit	Detroit	F.†	13.2	9.4	4.1	2.5	3 10	
			G.†	......	*18.0*	*4.0*	*8.0*		Corn meal, corn bran, gr. corn, gr. kaffir corn, wheat bran and middlings, charcoal, beef scraps, alfalfa meal, buckwheat hulls.
B 6313	Eagle Mash	Detroit	F.†	11.0	17.8	5.0	6.3	3 75	
			G.†	......	*11.0*	*2.5*	*4.0*		Wheat, buckwheat, peas, milo and millet.
B 6312	Eagle Pigeon Feed	Detroit	F.†	12.8	12.8	2.8	3.2	4 25	

			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, milo, wheat, barley, buckwheat, oats, screenings and sunflower.
B 6309	Eagle Scratch Feed, no grit	Detroit	F.†	13.7	9.8	3.8	1.8	3 25	
	Scholl & Rath, Monroe, Mich.								
			G.†	......	*12.3*	*2.6*	*3.7*		Cracked corn, wheat, barley, buckwheat, screenings.
B 6366	Waterloo Scratch Feed	Monroe	F.†	13.7	12.3	2.6	3.7	....	
	Standard Grocer & Mlg. Co., Holland, Mich.								
			G.†	......	*9.4*	*2.5*	*4.0*		Cracked corn, kaffir corn, wheat, barley, oats, chess and grit.
B 6501	Standard Scratch Feed	Holland	F.†	12.5	9.5	3.0	2.1	....	
	Stockbridge Elevator Co., Jackson, Mich.								
			G.†	......	*10.0*	*3.5*	*5.0*		Cracked corn, cracked milo, cracked wheat, cracked barley, cracked oat groats and millet.
B 6391	Seco Little Chick Feed	Jackson	F.†	12.0	10.7	4.0	2.5	....	
			G.†	......	*19.0*	*3.5*	*6.0*		Linseed meal, gluten feed, gr. corn, wheat brans and middlings, gr. oats, meat scraps, bone meal, alfalfa meal.
B 6389	Seco Egg Mash	Jackson	F.†	11.1	20.8	4.3	5.6	....	
			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats and sunflower.
B 6376	Seco Scratch Feed	Jackson	F.†	11.6	10.3	3.0	2.6	....	
	David Stott Flour Mills, Detroit, Mich.								
			G.†	......	*10.0*	*3.0*	*5.0*		Cracked corn, milo maize, wheat, barley, buckwheat, oats and sunflower.
B 6356	"Columbus" Scratch Feed	Detroit	F.†	13.4	10.7	2.7	2.4	....	
	Toledo Grain & Mlg. Co., Toledo, Ohio								
			G.†	......	*10.0*	*2.5*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats and sunflower.
B 6381	Camp's Red Ball Scratch Feed	Morenci	F.†	12.3	11.7	3.0	2.9	....	
	Tomlinson Watson Co., Detroit, Mich.								
			G.†	......	*10.0*	*2.5*	*5.0*		Linseed meal, cracked corn, kaffir corn, wheat, barley, buckwheat, oats and sunflower.
B 6304	Red Bird Scratch Feed	Detroit	F.†	13.1	10.6	3.2	2.2	3 50	
	Watson-Higgins Milling Co., Grand Rapids, Mich.								
			G.†	......	*9.0*	*2.0*	*8.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats.
B 6205	Perfection Scratch Feed	Greenville	F.†	12.7	10.7	3.0	2.6	3 25	
B 6280	Perfection Scratch Feed	Grand Haven		11.8	10.1	2.7	1.8	2 65	Same as B 6205, with rye and ergot, sunflower.
		Average		13.8	10.1	2.9	2.2		
	Wenonah Flouring Mills, Bay City, Mich.								
			G.†	......	*10.8*	*2.5*	*3.5*		Cracked corn, wheat, barley, buckwheat and oats.
B 6022	Chicken Feed	Bay City	F.†	14.1	10.8	2.5	3.5	2 90	
	Western Feed Mfgrs., Inc., Chicago, Ill.								
			G.†	......	*10.0*	*3.0*	*5.0*	....	Cracked corn, milo, wheat, oats, barley, buckwheat.
B 6156	Commercial Scratch Feed, no grit	Niles	F.†	11.4	9.6	3.0	2.5	....	
B 6289	Commercial Scratch Feed, no grit	Niles		11.1	9.8	3.4	2.3	2 50	Same as B 6156, with weed seeds and sunflower.
		Average		11.3	9.7	3.2	2.4		

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	POULTRY FEEDS—Concluded.								
	Western Feed Mfrs., Inc., Chicago, Ill.—Concluded.								
			G.†	......	*10.0*	*3.0*	*5.0*		Cracked corn, milo, wheat, barley, buckwheat, oats and grit.
B 5920	Commercial Scratch Feed, with grit	Lansing	F.†	11.7	9.6	3.6	2.0	$3 90	
B 6055	Commercial Scratch Feed, with grit	Flint		11.5	9.1	2.9	1.7	2 90	Same as B 5920.
		Average		11.6	9.4	3.3	1.9		
			G.†	......	*10.0*	*3.0*	*5.0*		Cracked corn, milo, wheat, barley, buckwheat, oats.
B 6056	"Rep" Scratch Feed, no grit	Flint	F.†	11.9	9.2	2.7	2.3	3 00	
			G.†	......	*18.0*	*4.0*	*8.0*		Linseed meal, corn feed meal, wheat bran and middlings, oats, meat scraps, alfalfa meal, skim milk, dried buttermilk and salt.
B 5923	Sincerity Egg Mash with Skim Milk and Dried Buttermilk	Lansing	F.†	10.0	**14.9**	4.5	7.8	4.60	
B 6058	Sincerity Egg Mash with Skim Milk and Dried Buttermilk	Flint		9.5	19.9	5.7	6.9	3 50	Linseed meal, gluten feed, corn feed meal, wheat bran and midds., gr. oats, meat scraps, alfalfa meal, dried skim milk, salt dried buttermilk, calcium carbonate.
B 6671	Sincerity Egg Mash with Skim Milk and Dried Buttermilk	Lansing		9.1	18.0	4.2	6.8	3 75	Same as B 6058.
B 6159	Sincerity Egg Mash with Skim Milk and Dried Buttermilk	Niles		9.6	**15.9**	5.0	7.9	....	Same as B 6058, without gluten feed.
B 6178	Sincerity Egg Mash with Skim Milk and Dried Buttermilk	Grand Rapids		10.6	17.4	5.3	7.7	3 50	Same as B 6058.
B 6287	Sincerity Egg Mash with Skim Milk and Dried Buttermilk	Niles		10.6	18.6	5.1	7.9	4 00	Same as B 6058.
		Average		9.9	10.5	5.0	7.5		
			G.†	......	*10.0*	*3.0*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats and sunflower.
B 5922	Sincerity Scratch Feed, no grit	Lansing	F.†	11.8	10.0	3.5	2.9	4 10	
B 6057	Sincerity Scratch Feed, no grit	Flint		12.1	10.4	2.9	2.5	3 00	Same as B 5922, with milo.
B 6177	Sincerity Scratch Feed, no grit	Grand Rapids		12.7	10.0	3.2	3.1	3 25	Same as B 5922.
		Average		12.2	10.1	3.2	2.8		
			G.†	......	*10.0*	*3.0*	*5.0*		Cracked corn, milo, wheat, barley, buckwheat, oats and sunflower.
B 6072	Sure Pay Scratch Feed, no grit	Lansing	F.†	13.6	9.6	3.1	1.9	3 25	

B 6155	Sure Pay Scratch Feed, no grit	Niles		11.4	10.0	3.1	2.6	......	Same as B 6072.
B 6288	Sure Pay Scratch Feed, no grit	Niles		12.1	9.2	3.4	2.2	2 60	Same as B 6072, with grit.
		Average		12.4	9.6	3.2	2.2		
			G.†	......	*10.0*	*3.0*	*5.0*		Cracked corn, milo wheat, barley, buckwheat, oats, grit.
B 5921	Sure Pay Scratch Feed, with grit	Lansing	F.†	12.3	9.8	3.4	2.4	3 90	
B 6054	Sure Pay Scratch Feed, with grit	Flint		12.1	10.1	2.7	2.3	2 90	Same as B 5921, with sunflower.
		Average		12.2	10.0	3.1	2.3		
	C. C. Wright Son & Co., Owosso, Mich.								
			G.†	......	*9.5*	*3.0*	*5.0*		Cracked corn, kaffir corn, wheat, barley, buckwheat, oats and sunflower.
B 6047	Wright's Mixture	Owosso	F.†	12.9	10.7	3.0	2.2	2 90	
	A. K. Zinn & Co., Battle Creek, Mich.								
			G.†	......	*10.0*	*2.5*	*5.0*		Corn, cracked corn, kaffir corn, milo, wheat, rye, barley, buckwheat, oats and sunflower.
B 6508	Peerless Scratch Feed	Battle Creek	F.†	12.2	11.3	3.3	2.8	2 50	
	WHEAT BRAN								
	Arkansas City Mlg. Co., Arkansas City, Kas.								
			G.†	......	*14.5*	*3.5*	*10.0*		
B 6142	Wheat Bran & Screenings	Conklin	F.†	10.5	17.6	3.3	9.3		
B 6148	Wheat Bran & Screenings	Charlotte		10.0	15.0	4.0	10.0		
B 6256	Wheat Bran & Screenings	Hudsonville		12.5	17.8	3.6	9.2	40 00	
B 6410	Wheat Bran & Screenings	Marshall		13.0	18.1	3.7	9.1	2 00	
		Average		11.5	17.1	3.7	9.1		
	Big Diamond Mills Co., Minneapolis, Minn.								
			G.†	......	*13.0*	*3.5*	*13.9*		
B 6266	Big Diamond Wheat Bran, with gr. screenings not exceeding mill run	Cadillac	F.†	10.8	13.9	5.0	11.8	40 00	
	J. P. Burroughs & Son, Flint, Mich.								
			G.†	......	*12.5*	*3.0*	*10.5*		
B 6051	Choice Winter Wheat Bran, with ground screenings not exceeding mill run	Flint	F.†	11.2	14.8	3.5	9.4	1 90	
	W. A. Coombs Milling Co., Coldwater, Mich.								
			G.†	......	*14.0*	*3.0*	*10.0*		
B 6211	Rob Roy Feed Winter Wheat Bran, with ground screenings not exceeding mill run	Coldwater	F.†	10.0	15.2	3.8	9.5	48 00	
B 6373	Rob Roy Feed Winter Wheat Bran, with ground screenings not exceeding mill run	Coldwater		10.0	15.9	3.5	9.3	......	
		Average		10.0	15.5	3.7	9.4		
	J. F. Eesley Mlg. Co., Plainwell, Mich.								
			G.†	......	*16.2*	*3.3*	*11.8*		
B 6522	Wheat Bran, mixed with screenings not over mill run	Plainwell	F.†	12.2	13.5	3.2	10.6	30 00	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	WHEAT BRAN—Concluded.								
	Everett Aughenbaugh & Co., Waseca, Minn.		G.†	.....	*14.0*	*3.0*	*12.0*		
B 6387	E-A-Co Wheat Bran	Jackson	F.†	10.6	15.6	4.7	9.8		
	The Goerz Flour Mills Co., Newton, Kas.		G.†	.....	*14.5*	*3.5*	*11.0*		
B 6186	Wheat Bran & Screenings	Nunica	F.†	13.5	17.8	4.0	8.1	$40 00	
	Goshen Milling Co., Goshen, Ind.		G.†	..	*14.5*	*3.5*	*11.0*		
B 6104	Wheat Bran and Ground Wheat Screenings	Eau Claire	F.†	9.7	16.9	3.8	8.9	......	
	Hankey Milling Co., Petoskey, Mich.		G.†	...	*13.5*	*3.7*	*9.5*		
B 6191	Bran, with mill run screenings	Petoskey	F.†	12.5	11.5	4.2	8.9	40 00	
	Ismert-Hincke Milling Co., Kansas City, Mo.		G.†	.....	*14.5*	*3.5*	*10.0*		
B 6336	I-H Bran	Detroit	F.†	11.1	16.7	4.0	8.7	33 00	
	The Larabee Flouring Mills Corp., Kansas City, Mo.		G.†	.....	*15.0*	*3.5*	*10.5*		
B 6385	Wheat Bran	Jackson	F.†	11.0	17.1	3.0	8.6	......	
	The H. D. Lee Flour Mills Co., Salina, Kas.		G.†	.....	*14.5*	*3.5*	*11.0*		
B 6232	Wheat Bran & Screenings	Holland	F.†	12.0	18.1	4.2	8.4	40 00	
	The Lindsborg Mill & Elev. Co., Lindsborg, Kas.		G.†	.....	*14.5*	*3.5*	*10.0*		
B 6393	Wheat Bran & Screenings	Ypsilanti	F.†	11.0	17.2	4.0	9.5	......	
	National Feed Co., St. Louis, Mo.		G.†	.....	*14.5*	*4.0*	*10.0*		
B 6026	Wheat Bran, with screenings not exceeding mill run	Bay City	F.†	10.5	14.1	4.4	9.7	2 30	
B 6103	Wheat Bran, with screenings not exceeding mill run	Muskegon Heights		10.4	15.6	3.9	8.7	51 75	
		Average		10.5	14.9	4.2	9.2		
	David Stott Flour Mills, Inc., Detroit, Mich.		G.†	.....	*14.5*	*4.0*	*12.5*		
B 6319	Spring Wheat Bran & Wheat Screenings	Detroit	F.†	11.2	16.9	4.6	9.4	35 00	
B 6351	Spring Wheat Bran & Wheat Screenings	Detroit		10.8	16.7	4.5	9.1	......	
		Average		11.0	16.8	4.5	9.3		

	Voight Milling Co., Grand Rapids, Mich.							
B 6181	Voight's Winter Wheat Bran, with ground screenings not exceeding mill run	Hudsonville	G.†	......	*14.5*	*4.0*	*10.0*	
			F.†	13.1	17.0	4.3	9.8	40.00
	WHEAT MIDDLINGS							
	The Arkansas City Mlg. Co., Arkansas City, Kas.							
			G.†	......	*16.0*	*3.5*	*5.5*	
B 6102	Standard Wheat Shorts & Screenings	Charlotte	F.†	11.8	17.1	4.1	4.6	......
B 6141	Standard Wheat Shorts & Screenings	Conklin		10.7	16.3	4.4	5.2	......
B 6147	Standard Wheat Shorts & Screenings	Charlotte		10.8	17.6	4.1	4.7	......
B 6411	Standard Wheat Shorts & Screenings	Marshall		13.4	18.5	3.2	4.8	2.00
		Average		11.7	17.4	4.0	4.8	
	Bay State Milling Co., Winona, Minn.							
B 6212	"Bay State" Wheat Standard Middlings & Wheat Screenings	Kalamazoo	G.†	......	*15.9*	*4.0*	*7.5*	
			F.†	11.1	16.8	4.9	6.6	54.00
	Big Diamond Mills Co., Minneapolis, Minn.							
B 6265	"Big Diamond Wheat Flour Middlings" with ground screenings not exceeding mill run	Cadillac	G.†	......	*16.0*	*4.5*	*8.9*	
			F.†	11.7	16.6	5.5	8.1	50.00
	J. P. Burroughs & Son, Flint, Mich.							
B 6050	Fancy Winter Middlings, with ground screenings not exceeding mill run	Flint	G.†	......	*11.0*	*3.0*	*4.0*	
			F.†	10.8	16.3	1.1	6.0	2.30
	Commercial Milling Co., Detroit, Mich.							
			G.†	......	*13.5*	*4.5*	*10.0*	
B 6038	Standard Wheat Middlings	Port Huron	F.†	11.5	16.3	4.1	7.5	45.60
B 6363	Standard Wheat Middlings	Detroit		10.8	17.1	1.5	7.7	.....
		Average		11.2	16.7	4.5	7.6	
	W. A. Coombs Milling Co., Coldwater, Mich.							
B 6374	Rob Roy Feed Winter Wheat Middlings, with ground screenings not exceeding mill run	Coldwater	G.†	....	*15.0*	*3.0*	*8.0*	
			F.†	10.7	17.0	4.0	7.6	
	Franke LaBudde Grain Co., Milwaukee, Wis.							
B 5907	Standard Middlings, with ground screenings not exceeding mill run	Howe	G.†					
		Howell	F.†	.....	*14.6*	*3.5*	*9.0*	
				9.5	15.0	5.0	9.8	58.00
	The Goerz Flour Mills Co., Newton, Kas.							
B 6185	Gray Wheat Shorts & Screenings	Nunica	G.†	...	*16.0*	*3.5*	*5.5*	
			F.†	13.0	17.0	4.0	5.2	50.00
	Huron Milling Co., Harbor Beach, Mich.							
B 6102	Jenks White Middlings	Harbor Beach	G.†	......	*14.0*	*3.0*	*8.0*	
			F.†	11.0	11.5	4.2	3.5	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Continued.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	WHEAT MIDDLINGS—Concluded.								
	The Ismert-Hincke Milling Co., Kansas City, Mo.								
			G.†	......	*16.5*	*3.5*	*8.5*		
B 6283	I-H Pure Fancy Wheat Middlings Feed	Muskegon Heights.	F.†	7.9	15.6	2.0	1.4	....	
	Lindsborg Mlg. & Elev. Co., Lindsborg, Kas.								
			G.†	......	*16.0*	*3.5*	*5.5*		
B 6394	Wheat Shorts	Ypsilanti	F.†	11.9	19.2	4.8	5.2	....	
	National Feed Co., St. Louis, Mo.								
			G.†	......	*16.0*	*4.0*	*9.0*		
B 6024	Wheat Middlings, with ground screenings not exceeding mill run	Bay City	F.†	11.5	16.9	4.6	6.5	$2 50	
	The Southwestern Mlg. Co., Kansas City, Mo.								
			G.†	......	*15.0*	*3.8*	*8.0*		
B 6044	"Red Turkey" Wheat Grey Shorts & Wheat Scourings	Parma	F.†	11.6	17.4	3.8	7.0	....	
	Star & Crescent Milling Co., Chicago, Ill.								
			G.†	......	*15.0*	*4.0*	*8.0*		
B 6133	Star Standard Middlings	Grand Rapids	F.†	10.5	16.3	5.0	6.7	40 00	
	David Stott Flour Mills, Detroit, Mich.								
			G.†	......	*15.0*	*4.0*	*9.0*		
B 6353	Pennant Middlings	Detroit	F.†	11.8	17.5	5.0	6.2	....	
	WHEAT MIXED FEEDS								
	The J. E. Bartlett Co., Jackson, Mich.								
			G.†	......	*15.7*	*4.6*	*8.3*		
B 6138	Fine Ground Wheat Feed	Jackson	F.†	12.2	15.1	4.3	3.5	....	
	Huron Milling Co., Port Huron, Mich.								
			G.†	......	*14.0*	*3.5*	*11.5*		
B 6401	Jenks Mixed Feed	Harbor Beach	F.†	11.6	12.6	3.5	7.2	....	
	David Stott Flour Mills, Detroit, Mich.								
			G.†	......	*14.5*	*4.0*	*10.5*		
B 6354	Honest Mixed Feed	Detroit	F.†	11.5	16.7	5.0	7.7	....	

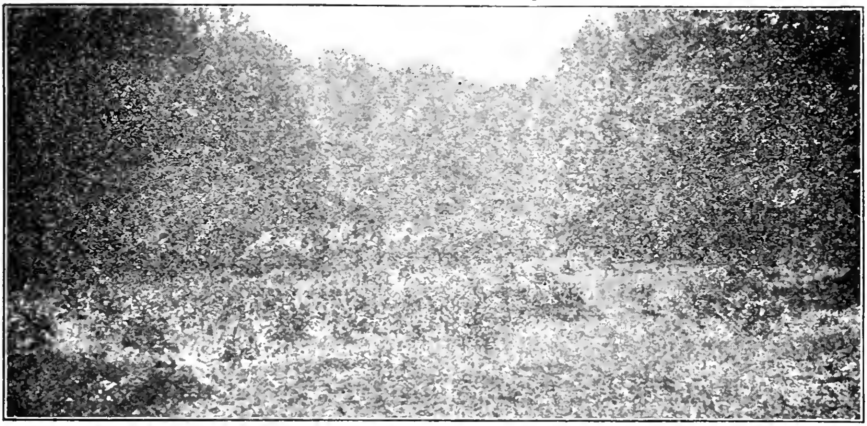
	WHEAT AND RYE MIXED FEED								
	Commercial Milling Co., Detroit, Mich.								
			G.†	......	13.0	4.0	9.0		
B 6364	Henkel's Fine White Feed	Detroit	F.†	11.6	17.8	3.3	4.8	....	
B 6039	Henkel's Fine White Feed	Port Huron		10.7	16.5	3.8	6.4	50.00	
		Average		11.2	17.2	3.1	5.6		
	The Quaker Oats Co., Chicago, Ill.								
			G.†	.....	15.5	4.5	11.0		
B 6089	Buckeye Feed	Ann Arbor	F.†	10.9	16.8	5.0	8.2	....	
	RYE FEED								
	W. A. Coombs Milling Co., Coldwater, Mich.								
			G.†	......	15.6	2.9	6.0		
B 6210	Rob Roy Rye Feed	Kalamazoo	F.†	11.6	15.7	3.1	4.7	2.80	
	MISCELLANEOUS FEEDS								
	Armour Grain Co., Battle Creek, Mich.								
			G.†	.....	12.0	0.2	1.5		
B 6503	Macaroni Feed	Battle Creek	F.†	9.7	14.8	0.4	0.4	25.00	
			G.†	.....	8.5	0.4	1.5		Wheat, corn and oat flour, sugar, acid calcium phosphate, sodium bicarbonate, powdered skim milk and salt.
B 6300	Pancake Flour Feed	Battle Creek	F.†	10.8	10.0	0.8	0.4	25.00	
	Chas. F. Bartlett Co., Grand Rapids, Mich.								
			G.†	....	12.0	12.0	12.0		Rice bran.
B 6225	Economy Rice Bran	Grand Rapids	F.†	10.0	13.3	13.8	10.9	37.50	
	Louisiana State Rice Mfg.. Co, Inc., New Orleans, La.								
			G.†	.....	12.0	12.0	12.0		
B 6221	Lastarmco Rice Bran	Coopersville	F.†	9.9	12.3	12.5	10.2	2.00	Rice bran.
	Commercial Milling Co., Detroit, Mich.								
			G.†	.....	9.5	3.5	9.0		Corn feed meal, wheat middlings, gr. oats and oat hulls.
B 6361	Henkel's Chop Feed	Detroit	F.†	10.8	9.2	4.3	5.2	....	
			G.†	.....	10.5	2.6	36.0		Buckwheat middlings and ground buckwheat hulls.
B 6365	Buckwheat Feed	Detroit	F.†	10.6	11.1	2.6	33.6	....	
	Cragin Products Co., Chicago, Ill.								
			G.†	......	18.0	8.0	14.5		
B 6073	Cragin Products Co. Kiln Dried Corn Distillers' Grains	Detroit	F.†	6.8	31.1	11.1	12.9	55.00	Distillers' grains.
	Franke LaBudde Grain Co., Milwaukee, Wis.								
			G.†	....	12.0	3.5	12.0	58.00	Barley feed and ground screenings.
B 5908	Barley Feed	Howell	F.†	9.0	13.4	3.9	13.4	58.00	

†Abbreviations for guaranteed and found.

ANALYSES OF FEEDING STUFFS FOR 1920-1921.—Concluded.

Laboratory number.	Manufacturer and trade name.	Sampled at.		Moisture.	Crude protein.	Crude fat.	Crude fiber.	Price per ton or cwt.	Principal ingredients identified.
	MISCELLANEOUS FEEDS—Concluded.								
	Kellogg Toasted Corn Flake Co., Battle Creek, Mich.								
			G.†	....	*12.5*	*0.8*	*3.9*		
B 6510	Broken Wheat Biscuit	Battle Creek	F.†	6.2	12.9	1.5	4.0	$42 00	Broken wheat biscuit feed.
			G.†	....	*15.5*	*2.5*	*10.0*		
B 6512	Cooked Bran Feed	Battle Creek	F.†	8.9	15.6	3.8	8.4	.....	Cooked wheat bran.
			G.†	....	*6.9*	*2.2*	*0.4*		
B 6509	Dried Corn Flake Feed	Battle Creek	F.†	4.9	8.8	1.5	1.4	35 00	Corn flake feed.
			G.†	....	*26.0*	*5.2*	*12.5*		
B 6513	Malt Feed	Battle Creek	F.†	4.5	28.3	5.6	11.5	....	Malt feed.
	Michigan Cereal Co., Port Huron, Mich.								
			G.†	....	*15.0*	*0.5*	*50.0*		
B 6040	Pea Bran	Port Huron	F.†	8.6	19.8	1.5	24.7	40 00	Pea bran.
	Michigan Sugar Co., Detroit, Mich.								
			G.†	.....	*8.0*	*0.5*	*20.0*		
B 6052	Dried Beet Pulp	Flint	F.†	8.3	8.9	0.8	18.2	....	Dried beet pulp.
	The Peoples Milling Co., Muskegon, Mich.								
			G.†	....	*9.0*	*3.7*	*7.0*		
B 6250	Corn Feed Meal & Ground Oats	Muskegon	F.†	13.9	8.9	2.6	4.7	37 00	Corn feed meal and ground oats.
	Postum Cereal Co., Battle Creek, Mich.								
			G.†	....	*8.0*	*1.8*	*22.0*		
B 6514	Barley Bran	Battle Creek	F.†	7.3	7.7	2.1	20.4	16 00	Barley hulls.
			G.†	.....	*17.0*	*3.0*	*20.0*		
B 6519	Burt's Cereal Feed	Battle Creek	F.†	6.2	18.6	3.1	18.5	10 00	Postum by-product.
			G.†	......	*6.0*	*0.2*	*2.0*		
B 6517	Cooked Corn Grits	Battle Creek	F.†	12.2	7.8	0.6	0.4	....	Cooked Corn Grits.
			G.†	.....	*8.0*	*1.0*	*2.0*		
B 6518	Flaked Corn Feed	Battle Creek	F.†	6.9	8.6	1.6	1.0	24 00	Corn flake feed.
			G.†	......	*9.0*	*0.5*	*2.5*		
B 6515	G-N Feed	Battle Creek	F.†	6.9	12.6	1.1	1.2	24 00	Grape nut feed.
	Saginaw Milling Co., Saginaw, Mich.								
			G.†	.....	*8.9*	*3.5*	*5.5*		
B 5911	C & O Chop	Saginaw	F.†	11.5	11.9	4.1	4.0	50 00	Ground corn, ground light oats and ground screenings.

†Abbreviations for guaranteed and found.



1. An Old Indian Corn Clearing

The farthest north and one of the most ancient of Michigan's Indian corn clearings, located on the banks of the St. Mary's River in Chippewa county.

These clearings were visited annually by the Indians for the purpose of planting and harvesting a crop of corn and were very numerous, particularly in the Lower Peninsula in the days of the early settlement of the State.

The following, quoted from a recent letter from Mr. Otto Fowle of Sault Ste. Marie, gives some interesting information in regard to the early history of corn growing by the Indians:—

"The Indian name for the river and vicinity was Mash-ko-de-sa-ging, which signified openings of fields near the rapids.

These fields were undoubtedly formerly cultivated by the Indians, on which were raised corn and squashes, but at a time beyond the memory of present inhabitants, and I find no written account of this cultivation more than that Jacob M. Howard, Attorney for the claimants in the Repintiguy case, visited this spot in 1862 and found a small encampment of Indians there.

The Jesuit Fathers who founded the Mission at the Sault in 1668, immediately began the cultivation of corn. Galinee, the Sulpitian priest who visited the Sault in 1680 writes, "They—the Jesuit Fathers—have a large clearing well planted from which they ought to gather a good part of their sustenance; they are hoping to eat bread within two years from now." This of course was corn bread, as wheat raising was not attempted.

In the trial of the Repintiguy case, referred to, which was in relation to events which occurred at the time of the building of the French Fort at the Sault-1751 to 1755, the following testimony was adduced: "He-Repintiguy-has engaged a Frenchman who married at the Sault Ste. Marie an Indian woman, to take a farm; they have cleared it up and sowed it and without a frost they will gather from 30 to 35 sacks of corn."

CORN GROWING IN MICHIGAN

Regular Bulletin No. 289

J. F. COX AND J. R. DUNCAN, FARM CROPS SECTION

Corn growing is one of Michigan's greatest industries. During the year, 1919, Michigan's corn crop was worth between $80,000,000 and $90,000,000, its value being greater than that of any other crop produced in Michigan. Michigan's corn growing counties are marked by thrifty herds of cattle and numerous flocks of hogs and sheep. The silo has extended her corn growing sections far to the north. The great stock-feeding and dairying interests, and the large food products industries of Michigan are largely supported by the corn crop. The production of corn compares favorably with Michigan's leading industries. The value of the corn crop approximately equals the total annual output of Michigan's copper mines, or iron mines, and exceeds the value of her furniture industry in normal years.

"The big business" of corn growing differs from other large industries such as automobile production, copper and iron mining, etc., in that its direction is not in the hands of a relatively few captains of industry, with specialists assigned to particular details of production, but it is owned and managed by several hundred thousand independent corn producers, each of whom must know the details of his business. The degree of success of the individual is largely in proportion to his knowledge of corn growing. Those who employ improved methods in selecting and storing seed corn, preparing the land, fertilizing and cultivating the crop, etc., are assured of a marked advantage over the corn grower who does not follow these methods. The prosperity of the State, and of individual farmers growing corn, is influenced in a large measure by the success of the corn crop, and it is to the interest of both the State and corn growers to secure the wide spread use of the methods which the most successful producers have found best.

For the past 15 years, Michigan's average production has been 53,000,000 bushels with an average yield per acre of 32.3 bushels. This average yield compares very favorably with the yield per acre of leading corn belt States, but double this yield or more can be expected on average corn land as a result of the employment of proper cultural methods. There is substantial reason to believe that greater care on the part of the majority of corn growers in choosing adapted varieties, selecting seed, preparing the land, and cultivating the crop, will bring about a very considerable increase in the total production and in the average yield per acre.

MICHIGAN CORN YIELDS

YEAR.	Acres harvested.	Average yield per acre.	Total production (000 omitted).	Average price December 1.	Total value (000 omitted).	Average value per acre.
	Acres.	Bushels.	Bushels.	Dollars.	Dollars.	Dollars.
1905	1,229,000	34.0	41,776	0.46	19,217	15.64
1906	1,475,000	37.0	54,575	0.44	24,013	16.28
1907	1,900,000	30.1	57,190	0.55	31,454	16.56
1908	1,900,000	31.8	60,420	0.64	38,669	20.35
1909	1,590,000	33.3	52,907	0.61	32,273	20.31
1910	1,670,000	32.4	54,108	0.53	28,677	17.17
1911	1,690,000	33.0	55,770	0.65	36,250	21.45
1912	1,625,000	34.0	55,250	0.57	31,492	19.38
1913	1,675,000	33.5	56,112	0.67	37,595	22.44
1914	1,750,000	36.0	63,000	0.67	42,210	24.12
1915	1,750,000	32.0	56,000	0.68	38,080	21.76
1916	1,650,000	27.5	45,375	0.95	43,106	26.12
1917	1,750,000	21.5	37,625	1.82	68,478	39.13
1918	1,610,000	30.0	48,300	1.30	62,790	39.00
1919	1,650,000	39.0	64,350	1.38	88,803	53.82
Average	1,660,933	32.3	53,517	0.79	41,540	24.90

The foregoing table, compiled by Mr. V. H. Church, Federal Crops Statistician of Lansing, Michigan, gives acreage, yields and prices of the Michigan corn crop for the past 15 years.

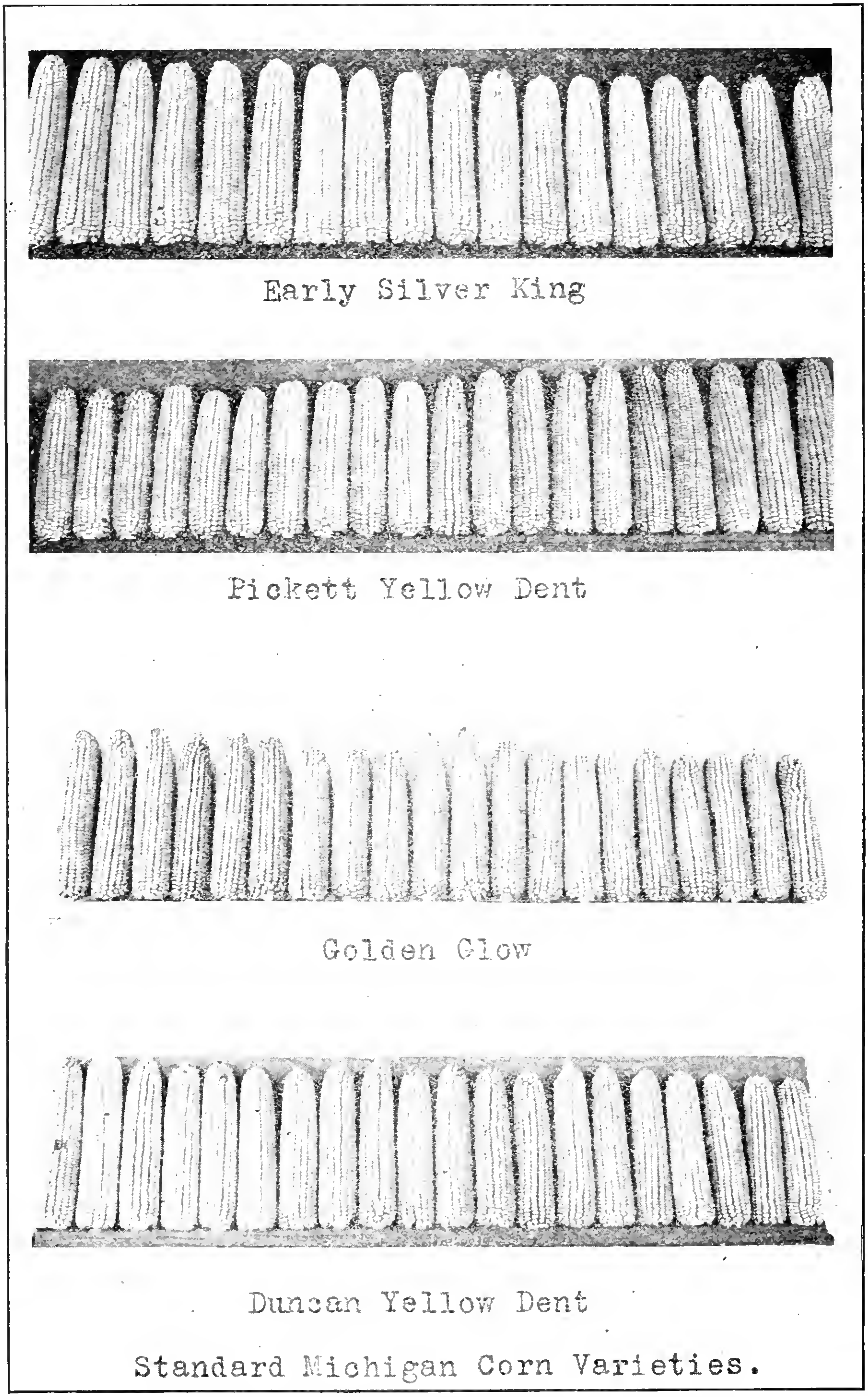
MICHIGAN CORN VARIETIES

The study of corn in Michigan corn fields, stored in Michigan corn cribs, or assembled for exhibit at local corn shows has established the fact that in many localities there are too great a number of varieties. It is not uncommon to find as many as thirty or forty different varieties exhibited at a single corn exhibit. These varieties vary markedly in appearance, ranging from carefully selected strains of proper adaptation and high yielding ability to varieties apparently too late or too early in maturity for the community and showing little improvement through breeding. The range in color includes the standard yellow, white and white cap varieties, and strains of red, red splashed and blue corn, and frequent mixtures.

Careful variety tests have proven that these varieties vary as much in yielding ability as in appearance, certain ones being capable of yielding many bushels more under the same conditions than the majority of the varieties in the tests.

THE BEST VARIETIES SHOULD BE ACCEPTED AS STANDARDS

Fortunately there are men in practically all Michigan corn growing sections who have taken great interest in the development of well adapted and high yielding strains of corn, and who have, by years of careful selection, laid a foundation for the standardization of Michigan corn varieties. It is of the utmost importance to the individual grower and to the corn crop of the State that these better varieties be more widely



2. SOME STANDARD MICHIGAN CORN VARIETIES
The Early Silver King and Duncan are well adapted to southern Michigan. The Golden Glow and Pickett are widely distributed, and adapted strains are grown in southern, central, and northern corn growing sections.

grown in the sections in which they are superior. It is also important that the methods of selection, and care of seed employed by Michigan's best corn growers in the development of these varieties be more widely employed.

By observing the yielding ability in the field of improved varieties for a number of years and assembling these varieties and numerous others of promise in carefully conducted variety tests throughout the State and at the Michigan Experiment Station, it has been made possible to designate, according to sectional adaptation, the leading corn varieties, which may be taken as dependable standards. Without doubt future experiments with corn varieties may develop even better strains and establish new varieties, which may replace many of the present ones, but it is certain that the varieties here designated have proven their adaptation and yielding ability, and are much superior to the majority of ordinary varieties usually grown.

APPROXIMATE SECTIONAL ADAPTATION OF LEADING MICHIGAN CORN VARIETIES

Section 1—Southern Michigan:

The Duncan Yellow Dent, Early Reed's Yellow Dent, Early Leaming, Murdock, Early Silver King, Folks White Cap, Golden Glow, Lawrence Yellow Dent, and Pickett Yellow Dent.

For silage these varieties and varieties from northern Ohio, northern Indiana, northern Iowa, and northern Illinois which are early enough to reach the dented and glazed kernel stage of maturity.

Section 2—Central Michigan:

Pickett Golden Glow, Geddes Early Silver King and Folks White Cap.

For silage, these varieties, and varieties from Section 1.

Section 3—Northern Michigan:

Early Golden Glow, Wisconsin 12 and No. 25, Early Pickett, Northwestern Dent, Ogemaw White Cap and Flint varieties.

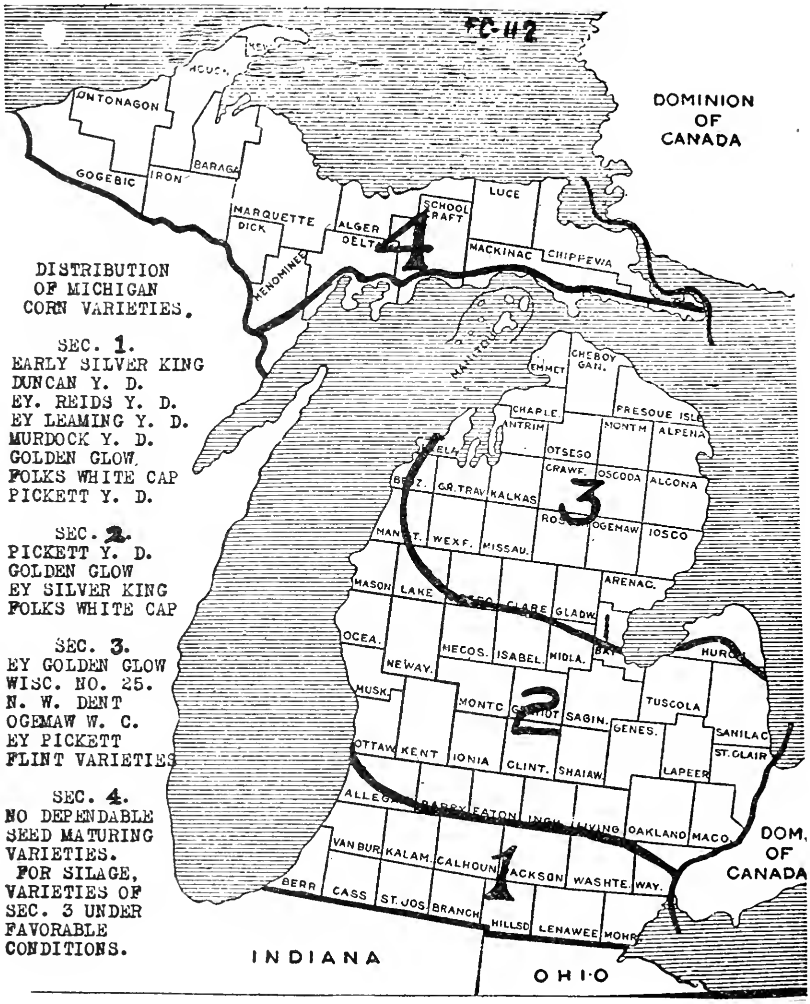
For silage—these varieties, and varieties from central Mchigan.

Section 4—

No safe grain maturing varieties. The varieties of Section 3, are recommended for silage under conditions where silage can be produced.

The accompanying map shows graphically the approximate adaptation of varieties listed. It must be kept in mind that definite boundaries cannot be established, and that exceptionally cold and late soils in southern localities require early strains such as are characteristic of more northern sections, while favorably located, quick growing corn soils in northern sections, particularly near Lake Michigan, can produce later strains than the average soil of the region.

County Agricultural Agents and the Farm Crops Department of the Michigan Agricultural College are in position to give information concerning varieties and source of dependable seed for established corn growing sections.



3. Map indicating approximate sectional adaptations of leading Michigan corn varieties.

DESCRIPTION OF MICHIGAN CORN VARIETIES

In order to give definite information concerning varieties of known excellence as shown by variety tests, the men who developed these varieties, or have grown them for a number of years, were requested to state the methods followed in establishing their respective varieties. A brief summary of the history of each variety is included with following description:

EARLY SILVER KING

The Early Silver King is a white variety introduced into Michigan from two sources; from northern Iowa, where it originated, and Wisconsin, where it has been widely distributed after selection and adaptation, as the Wisconsin No. 7. The ear is usually from 8½ to 9½ inches in length and 6¾ to 7¾ inches in circumference. It ranges in season from 100 to 130 days. Food products industries using corn pay a premium for white corn. The following men who have been instrumental in introducing this variety have given brief statements of source and selection methods:

Farley Bros., Albion, Calhoun county, secured seed of Silver King seven years ago from northern Iowa. They followed hill selection and saved the best type of ears for seed. The estimated maturity is 110 to 120 days on soils of variable Coloma loam.

Mr. C. P. Milham, Kalamazoo, Mich., secured Wisconsin No. 7 strain of Early Silver King from Wisconsin nine years ago. He has practiced field selection of ears on the stalk for his own seed and selected for type from this field selected seed.

His soil is mostly clay loam or sandy clay loam. The average length of season required for maturity for this strain of Wisconsin No. 7 is 110 to 125 days.

Mr. D. A. Geddes, Swan Creek, Saginaw county, secured Early Silver King or Wisconsin No. 7 from Wisconsin nine years ago. It has been his practice to always gather seed before corn was harvested, picking the early maturing ears from hills containing 2 to 4 strong, well developed stalks, saving the ears that were 8 to 9 inches long, carrying 16 to 20 rows, with good length of kernel at the tip and butt, growing about half way up the stalk, the ears drooping slightly so that rain would not injure tip of ear.

The soil is a clay loam. The estimated time for maturity is from 100 to 115 days.

PICKETT YELLOW DENT

The Pickett Yellow Dent is one of the oldest and best established varieties of lower Michigan. The ear is cylindrical and slightly tapering, measuring from 7 to 9 inches in length and 6½ to 7½ inches in circumference. The number of rows vary from 16 to 20. The kernels are medium to deep, compactly arranged on cob. Adapted strains of this

variety are safe throughout Sections 1 and 2. It produces a medium stalk growth.

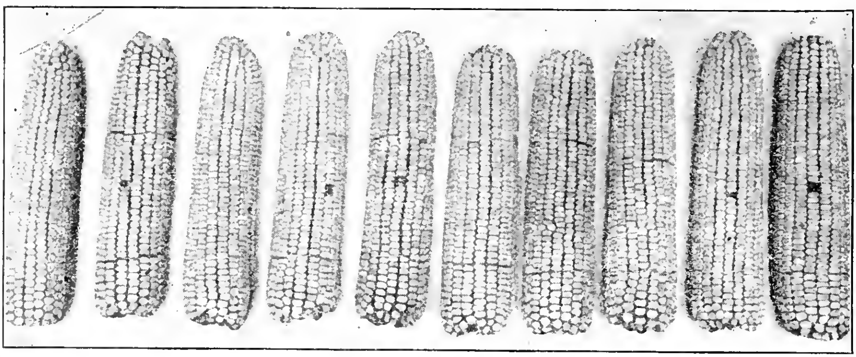
The Pickett variety is one of the most carefully selected native strains. It originated from a distribution of extremely early Reid's Yellow Dent, secured by the Michigan Agricultural College from northern Illinois in 1885. The original strain was too late for widespread success when introduced. After years of careful selection it has been made dependable over a wide area.

Mr. J. W. Pickett of Caledonia, Kent county, states the following regarding the Pickett variety:

Mr. W. E. Boyden, Delhi Mills, Michigan, secured some seed from the Michigan Agricultural College and grew it in 1889. Mr. Pickett secured seed from Mr. Boyden in 1890 and has grown it ever since.

The ordinary method of saving the best type of ears at cutting time and husking time was followed until 1906. In 1906 he commenced to improve his corn by testing out several selected ears by the ear row test and remnant method, planting a part of each ear and preserving the remainder for the purpose of bringing the high yielders together the following year in a breeding plat. He has followed these methods with modifications since that date.

According to type selected, the Pickett corn requires from 95 to 110 days for maturity. This variety was developed on clay loams and loams.



4. PICKETT YELLOW DENT

One of Michigan's oldest and most highly improved varieties. Known as a dependable grain maturing variety in southern and central Michigan.

DUNCAN YELLOW DENT

The Duncan Yellow Dent was developed by Mr. J. R. Duncan of Vicksburg, St. Joseph county. This variety is fairly well known in southern Michigan counties. The ears range in size from 8 to 9 inches, and carry 16 to 20 rows of kernels. The kernels are keystone shaped, medium deep, with remarkably large germs. The stalk is broad leafed and vigorous.

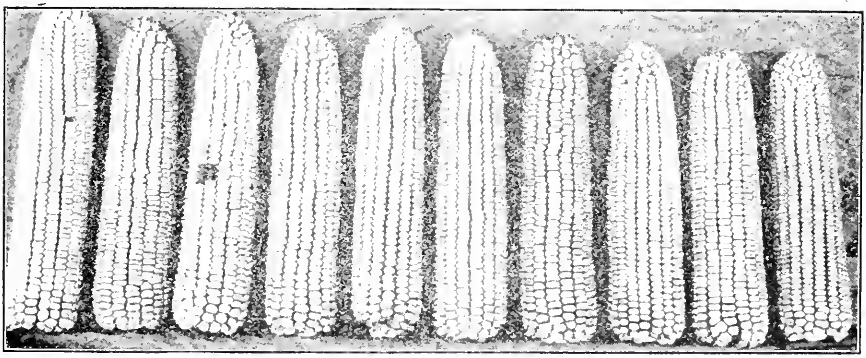
The seed which formed the basis of the present variety was bought in 1908 at Ossian, Indiana.

The method of selection followed was as follows:

Selection always from standard stalks. Ear to row work followed two years. Briefly stated, the best ears from strong, medium sized,

disease free stalks, standing in a full hill and surrounded by a full stand, were selected in the field before husking time. The best type from these ears was later selected for seed. The average length of season required for maturity is 110 to 130 days. The soil on which the Duncan was developed is a loam, fairly light in nature.

At present Willis Wahl and Schrader Bros. of Centerville, Michigan, are continuing the work of improving this variety in St. Joseph county. Earlier strains of Duncan, which have been brought out by ear row work at the Michigan Agricultural College, will be distributed in 1920 and 1921 throughout central Michigan.



5. DUNCAN YELLOW DENT

An excellent variety for southern Michigan and well liked for silage purposes in south-central counties.

THE GOLDEN GLOW VARIETY

This yellow dent variety was introduced from Wisconsin. It is a vigorous grower of wide adaptation. The ears are of a golden yellow color, slightly tapering, 7 to 9 inches in length, and from 6½ to 7¾ inches in circumference. The kernels are of a keystone shape for southern Michigan strains and a keystone to round for northern Michigan. The rows number 16 to 20.

Strains of this variety are grown in all Michigan corn growing sections. It is of particular importance in the central and northern districts.

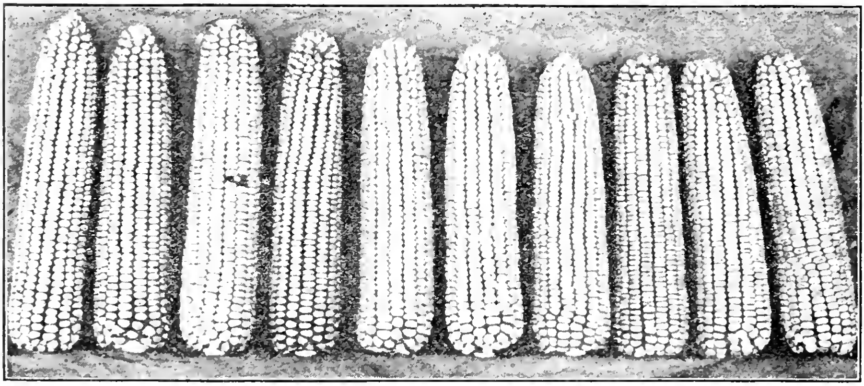
Mr. C. V. Town, of Greenville, Montcalm county, states the following in regard to Golden Glow:

He secured seed four years ago from Jefferson county, Wisconsin. Selected seed from portions of the field where the most perfect development was to be found, avoiding the high ground where for lack of moisture the fertile plants might become dwarfed in any way. He also avoided the low places where lack of fertility might cause undue stalk growth and a tendency to late maturity. He selected seed from stalks where stand is full, avoiding the ear set on long shanks, or ears set too high or too low on the stalk. In selecting seed ears Mr. Town avoided ears with course, open butts or long tapering tips with pointed kernels.

Mr. Town began ear to row work in 1919 with 55 ears from the best

stock obtainable from above method of selection. His soil is mostly clay loam, and time of maturity estimated at 110 to 120 days.

Mr. Olaf Nelson, Aloha, Cheboygan county, states that the original source of the Nelson's Golden Glow was the Wisconsin Golden Glow of an early strain from Wisconsin. The selection has continued 4 years in Cheboygan county.



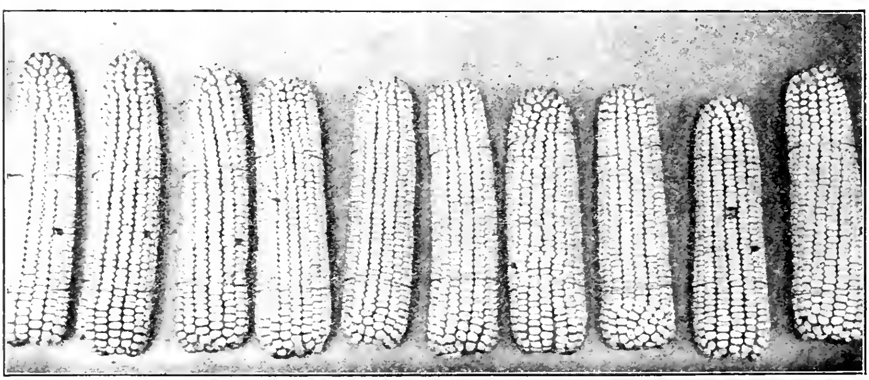
6. GOLDEN GLOW.

A widely adapted variety. Larger strains are available for southern Michigan, earlier strains for central Michigan, and extremely early Golden Glow is grown in northern counties.

The seed is carefully field selected, saving those ears true to type, such ears as are fully matured and free from disease. The seed is hung in the seed house, kept from frost and dried by artificial heat.

Early maturity is one of the chief points considered in selection work.

The soil is loam with clay sub-soil. The time of maturity is 95 to 105 days.



7. FOLKS' WHITE CAP.

A high yielding, early maturing variety, well adapted to south central and southern Michigan. (Sec. 1 and lower part of Sec. 2)

EARLY GOLDEN GLOW—WISC. NO. 12 & 25

The Wisconsin No. 12 usually matures in northeastern Michigan, with only occasional failures. It produces fairly large ears, kernels rather short, and cobs somewhat large for damp autumn seasons. This strain of Golden Glow is adapted to Section 3, particularly the southern and western area.

The type Wisconsin No. 25, of early Golden Glow matures about 10 days earlier than type No. 12. The kernels are rather short and ears about the size of the Ogemaw White Cap. The stock of No. 25 was obtained from the northern Wisconsin Experiment Station at Spooner, Wis. This early strain is best adapted to northeastern Michigan and the upper regions of Section 3 and Section 4.

FOLKS' WHITE CAP

This variety was developed by Mr. William Folks of Hanover, Jackson county. It is an exceptionally uniform white cap variety and has given excellent yields in southern and south central Michigan variety tests. It has a vigorous stalk and is highly appreciated both for grain and silage purposes. The ears range from 7 to 9 inches, are slightly tapering, and carry 16 to 20 rows of kernels of medium depth. Mr. Folks has given attention to the selection and improvement of this corn since 1905. It is one of the best yielding varieties for southern Michigan.

LAWRENCE YELLOW DENT

This variety was originated by Mr. L. L. Lawrence, of Decatur, Mich. It is a yellow dent variety, well adapted to southwestern Michigan. The ear ranges from 8 to 9½ inches in length, carries from 16 to 22 rows of kernels. The kernels are of medium depth, and the indentation is rough.

Mr. Lawrence states that he "has grown this corn upwards of 20 years on slightly sandy loam, underlain with clayish, gravelly sub-soil." He has practiced hill selection and estimates the maturity of his corn at 100 to 120 days. The original strain was a Turkey-track type. The present strain of Lawrence Yellow Dent shows only occasional red hull markings.

EARLY REID'S YELLOW DENT

The early strains of Reids' Yellow Dent mature safely in Michigan's southern-most counties. The leading variety in Branch county variety tests, for the past 2 years, has been an Early Reids', grown by Mr. Coffman for the past 11 years.

The ears are from 9 to 10 inches in length and carry 16 to 20 rows of kernels. The color is medium yellow, the sides of kernels being slightly darker yellow than crown. The kernels are broad and fairly deep, with large germs, and compactly arranged in row. The cob is small, ears cylindrical, butts and tips well curved.

This variety matures safely in favorable locations of Michigan's southern tier of counties and is utilized as a silage variety throughout southern Michigan.

EARLY LEAMING

The Leaming is recognized as one of the oldest varieties. It has undoubtedly formed the foundation of several Michigan corn varieties. Earlier strains of Leaming mature in southern Michigan and it is well known as a silage variety in southern and central Michigan. The ears vary from 7½ to 9 inches in length and are characterized by a distinctly tapering shape. The indentation of kernel is smooth, grains medium to deep and variable in thickness. The color of Leaming is a medium yellow tinged with golden. This variety is too long seasoned to be grown safely, except on the good corn growing soils of southern Michigan counties.

MICHIGAN YELLOW DENT

This variety, developed in Jackson county, is grown chiefly in southeastern Michigan. The ears are from 8 to 9 inches in length with 16 to 18 rows of kernels of medium depth and medium indentation. The ears are symmetrical and quite uniform. This type is dependable in yield and adaptation in southern Michigan counties.

PRIDE OF MICHIGAN

The Pride of Michigan is a yellow dent variety of long standing in southern Michigan. Early strains are established as far north as Saginaw county. The type is thoroughly acclimated in southern Michigan. The ears are uniform in size, slightly tapering, being from 8 to 10 inches in length with 16 to 20 rows of kernels of medium depth. Color is light golden. This variety is recommended for southern Michigan and early strains for central Michigan.

NORTHWESTERN DENT

The original stock of the Northwestern Dent variety was secured from North Dakota, 8 years ago by Mr. E. E. Evans of Ogemaw county. As received, the stock was mongrel, showing variations from dark turkey red to yellow and many types of kernels:—Dent, Hackberry, and Flint. The improved strain of Northwestern Dent bears little resemblance to the original stock. The cobs are small, drying out readily and quickly. The kernels are the deepest of any dent corn grown in northern Michigan which matures regularly; color, reddish with pale caps. Light colored ears appear rarely in improved stock.

This stock matures safely in north-central Michigan.

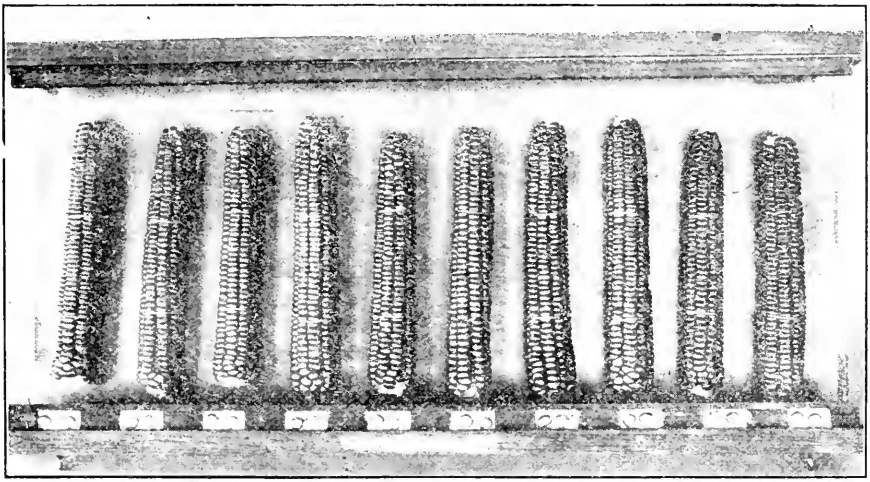
OGEMAW WHITE CAP

The Ogemaw White Cap is a white cap variety, 5 to 6 inches long, maturing in from 90 to 100 days and adapted to northeastern Michigan. It was originated by Mr. E. E. Evans of West Branch, Ogemaw county, from stock obtained from Calhoun county 26 years ago. This variety is a standard variety of Ogemaw and neighboring counties.

EARLY FLINT VARIETIES

Early Flint varieties are as a rule the earliest grain maturing varieties. The 8-Row Yellow, Early Mohawk, King Philip, Smut Nose or Red Blazed, and Rainbow Flint are the best known Michigan varieties. Of these the 8-Row Yellow is one of the earliest, maturing in from 80 to 90 days.

The Smut Nose or Red Blazed Flint is one of the most widely grown flint varieties. The color is yellow, and the tips of smutty or bronzed appearance. The ears are usually 8 rows, from 9 to 11 inches in length. The stalks are about 7 feet high.



8. Flint varieties are adapted to regions of short seasons in northern Michigan, and are used occasionally for replanting or planting at late dates in southern and central Michigan.

The King Philip Flint is one of the oldest varieties and known as a productive strain, often bearing several ears per stalk. The ears are from 10 to 13 inches long; the color deep red with occasional light crowned kernels. It is shown as a hardy flint variety and is a vigorous stalk producer.

The Early Mohawk was developed in northern Michigan counties from a variety from New England. It is a large type with ears from 10 to 13 inches long; red in color, with lighter color at crowns of kernels.

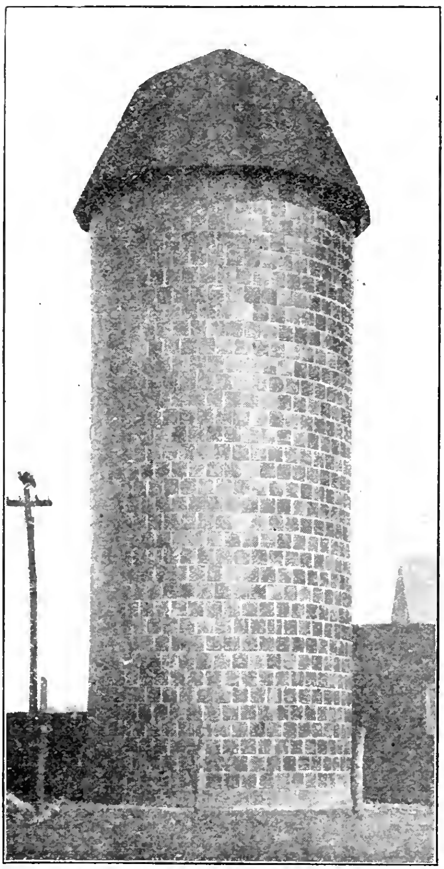
The Rainbow Flint is a mixed vari-colored strain found growing in Alpena and Presque Isle counties.

The Yankee Dent or Poorman's corn is an early variety intermediate between Dent and Flint, having broad, shallow, pale yellow or cream colored kernels. This variety is adapted to sections of short seasons and poor soils, and is sometimes used for replanting or planting at late dates in central and southern Michigan.

Flint varieties are adapted to planting in sections with too short a season for the proper maturity of Dent varieties. During recent years early types of Dent corn have rapidly replaced the Flint varieties.

VARIETIES FOR SILAGE

The highest yields of food material per acre are secured from corn which reaches maturity. Under average conditions, a variety which reaches the dented and glazed kernel stage of maturity, with the lower leaves of plant turning brown, will produce the most nutritious and most palatable silage. Approximately two-thirds of the digestible food value of corn is in the ear, and hence varieties which produce a good ear will make silage of richest feeding value. It is possible, however, to grow varieties that will not produce sufficient tonnage and mature too early for ensilage. Large growing leafy plants, which will produce ears that reach the dented and glazed stage or hard dough stage of maturity, fill all requirements. Corn which has reached full maturity is usually too dry to produce the most palatable silage, even though water is added.



9. The silo has extended Michigan's corn growing section far to the north and provides insurance against loss of crop during seasons of early fall frosts.

The Silver King and Duncan varieties, for instance, are splendid silage varieties in central Michigan, while in southern Michigan Reid's and Leaming, of northern Ohio and northern Indiana, make excellent silage corn. In northern Michigan the Golden Glow, and Early Silver King from central Michigan, make good silage.

Extremely large growing types, such as the Red Cob Ensilage, furnish a large yield per acre of silage material, carrying a much higher water content and less food value than silage of greater maturity. The dairyman, living near large cities with a limited acreage, who buys most of his feed, may find these types of use in giving him the largest yield of succulent roughage per acre on his high priced land. The average dairyman and farmer, however, usually has plenty of land and is more limited in silage space and desires to save as much as possible on concentrates. For him, a thrifty variety which reaches a more advanced stage of maturity is the best for silage.

VARIETY TESTS FOR CORN

In view of the variability of the soil and climatic conditions in Michigan, and hence the great variation in adaptation of corn varieties, the Farm Crops department has found it advisable to conduct numerous corn variety tests well distributed over the State, as well as at the Experiment Station.

These tests show that there is a great difference in the yielding ability of varieties grown in all Michigan corn localities. Some strains will out-yield others by 40 to 50%. Taking the year 1919, for example, in 24 tests the average of the highest yielding varieties was 59.21 and the average of the lowest yielding varieties was 35.44 a difference of 23.77 bushels.

Without doubt, if the leading varieties of various districts were adopted as standards, corn yields would be greatly increased. Corn variety tests, the past few years, have shown that there are many local varieties of merit which should be more widely grown.

The accompanying table, No. 2, gives the yields of typical varieties in tests held in a number of Michigan counties in 1919.

Table No. 3 gives the yields of a number of representative Michigan corn varieties in variety tests conducted at the Michigan Agricultural College.

TABLE NO. 2—

*SECTIONAL VARIETY TESTS—CORN 1919

YIELDS OF STANDARD AND LEADING VARIETIES

(BUSHELS PER ACRE)

SOUTHERN

County.	No. in test.	Golden Glow.	Duncan.	Folks White Cap.	Pickett.	Geddes Ely Silver King.	Milham's Ey. Silver King.	Putnam's Golden Glow.	High Yield.	Low Yield.	Range in Yield.
Barry............	11	58.9 (H) 48 90	55.50	55.64	45.61	31.95	56.88	34.6	58.90	31.95	26.95
Branch A1.........	8	49.00	42.50	39 40	....	....	43.9	....	Reids Y. D. 56 10	39.40	16 70
Branch B1.........	14	40 00	32.57	34 50	36.70	....	43 8	....	Murdock 48.3	26.90	21.40
Cass..............	10	50 20	30 30	48 70	50 50	....	45 00	....	50 50	30.30	20.20
Calhoun...........	6	45.64(H) 50 43	37 30	40 76	32 68	....	....	46 0	50 40	32 68	17.72
Livingston.........	7	46 11	44 06	56 44	36.68	43 10	40 91	41.99	56 40	36 68	19.72
Monroe...........	10	110 8	139 00	102 7	96 80	101 0	127 20	90 72	139 20	90.72	48.48
Shiawassee.........	12	60 66	44 28	46 33	54 63	45 48	50 96	52 66	60 66	42 50	18.16
A. Van Buren.........	19	33 91	36 86	35 53	32.17	40 30	31 08	30 09	Bennett. W. C. 41 50	19 20	22 40
B. Van Buren	15	36 26	35 06	36 70	35 30	28 50	32 90	30 2	36 70	21 50	15.20
C. Van Buren	12	36.11	....	....	30 50	21.42	....	37.68	36 11	21.00	15.11
Wayne...........	11	52 89	68 69	42 44	48 50	48 83	44 26	46.74	68.69	42 44	26 25
CENTRAL											
Kent.............	12	27.81	23.65	15 98	25 97	17 73	25 63	32 95	32.95	17.10	15.85
Tuscola...........	10	70 60	....	74.30	81 8	60 00	77.20	77 4	Local Y. D. 103.00	60.00	43.00
NORTHERN											
Cheboygan........	12	35.82	39.09	....	41.61	....	....	65 00	65.00	30.34	34.66
Benzie Co. Average 8 tests	17	38.40 N 29.85 T	....	40.00	....	42.29	....	39.96	42.00	23.00	19.00
Averages 24 tests ..	......	....	....	....	....	....	....	....	59.21	35.44	23.77

*Complete data for each test can be secured from the Farm Crops Department.
H. Hoopingarner's Golden Glow.
N. Nelson's Golden Glow.
T. Towne's Golden Glow.

The above summary of twenty-four variety tests shows an average range in yield of 23.77 bushels between the highest and lowest yielding varieties. It indicates the need of such tests covering a series of years in all corn growing localities in order to ascertain which standard or local variety is best suited to be accepted as the best variety for the locality.

TABLE NO. 3—

VARIETY TEST, EXPERIMENT STATION 1919

Variety Name.	Market Quality.	Moisture in %.	Shelling %	Bushels per acre including 14% moisture.
Golden Glow (check)	793	352	863	86.35
Duncan	756	409	864	78.32
Early Silver King	822	392	849	76.39
Golden Glow (check)	825	352	863	86.35
Pickett	731	348	876	70.96
White Cap Folks	703	37	876	81 64
Golden Glow (check)	863	352	863	86.35
Pride of North	703	417	864	56.23
White Cap Ogemaw	677	29.5	83.8	49.43
Golden Glow (check)	785	352	863	86 35
Golden Glow B. Wisc	832	351	852	85 90
Golden Glow M. Wisc	698	301	848	70.97
Golden Glow (check)	743	352	863	86.35
Shovar Y. Dent	751	339	864	77.98
E. Silver King, Saginaw	725	335	882	74.11
Golden Glow (check)	778	352	863	86.35
Golden Glow	728	30	849	62.97
Golden Glow, Cheboygan	667	324	846	67 23
Golden Glow (check)	807	352	863	86.35

THE LESSON OF 1917 AND 1918

The costly and almost disastrous experience of 1917 and '18, demonstrated beyond argument that the ordinary methods of selecting and curing seed corn practiced up to that time, were not dependable. The safety of the entire crop was endangered by the abnormal weather conditions of the fall of 1917, and extremely severe winter weather of 1917 and '18, and the lack of widespread selection in the field and proper curing of seed corn. Even in an average season there is a great loss in yield through the failure on the part of a great number to follow proper methods of seed selection.

During the early spring of 1918, it was necessary for the Michigan War Preparedness Board to secure from outside sources approximately 100,000 bushels of seed, or about two-fifths of the seed corn planted in Michigan, in order to plant a nearly normal acreage. This corn was brought largely from New York, New Jersey, Delaware and South Dakota. The eastern corn was of high germination and proved to be excellent for ensilage purposes. The western corn was not in such good condition, but proved in many instances, to be well adapted for grain purposes and will undoubtedly prove to be of lasting influence, particularly the Wimples and Silver King varieties distributed in southern Michigan.

The dire conditions resulting from the adverse conditions of 1917 and '18, were met successfully, chiefly due to the fact that Michigan's War Board realized the great importance of the corn crop, during war

times, and advanced approximately $350,000 to serve as a revolving fund for the purchase of seed corn. Their action resulted in securing enough seed at an early date for the production of an almost normal crop. During peace times, it is extremely doubtful that a like fund could be made available. Should the same weather conditions result as in the fall of 1917, and find the same methods followed in selecting seed, Michigan farmers would face a much greater loss than was experienced in 1918.

The wide spread field selection of seed corn in the fall and the proper storing of early selected ears would make such a calamity to the corn crop, as was threatened in 1917, impossible, and would greatly increase annual returns. It is sincerely hoped that a number of favorable seasons will not lull Michigan farmers into a sense of false security, and that the practice of field selection and proper storing of seed corn will be more wide spread than it was even in the fall of 1918, following the great seed corn famine.

No two factors will go further toward immediately increasing the yields of corn in Michigan, than the proper selection and handling of seed corn.

SELECTING AND CURING SEED CORN

The common practices of selecting seed corn from the crib or when husking the general crop are too costly to be continued. Such corn usually germinates poorly and may result in poor stands. It is extremely important that the most mature and highest yielding corn of each season's crop be selected in the field and properly stored to furnish seed for planting the next spring.

ADVANTAGES OF FIELD SELECTING SEED CORN

The great advantage of selecting seed corn in the field before the crop is harvested lies in the fact that mature corn is secured and that a study of the plant on which the ear grew and of its environment can be made. In selecting from the shock or from the crib little is known of the parent plant or the conditions under which it grew. Corn which has stood in the shock or in the crib is more or less seriously injured by the development of molds or by freezing while in a moist condition.

It has been demonstrated that the corn plant is easily altered by proper selection methods. Yield, time of ripening, position and character of ear and even feeding value can be changed within wide limits. Field selection and proper storing as compared with prevailing selection methods will usually increase the yield of ordinary corn varieties from seven to ten bushels per acre. Enough corn to plant twenty acres can be easily field selected in a day's time by one man. With a seven-bushel increase per acre the corn grower who plants twenty acres of corn will be rewarded with 140 bushels in his next season's crop or at present prices $140 a day or more for his labor in field selecting and storing—admittedly a profitable day's work.

HOW TO FIELD SELECT CORN FOR SEED

The proper time to field select seed corn is in late September or during October when corn is sufficiently mature and ready to husk. In making the selection, the best way is to walk down the rows with a sack tied over the shoulders, or carrying a basket, plucking those ears which are considered desirable. Mature ears borne on vigorous plants growing under average conditions, which are carried at the right height, about the center of the stalk or just below, and with tips slightly drooping, should be selected, then properly stored. Ears should not be taken from lodged or "down" stalks, since the root systems of such plants may have been weakened by fungous diseases, which may be carried in the seed.

If field is to be harvested for silage, or is immature, due to early frost, vigorous plants carrying heaviest and most mature ears should be cut and shocked at edge of field. After standing for several days or until ears are firm, the ears should be husked and cured for seed.

Further selection for uniformity of type and composition can be made through the winter or when making the germination test. By proper field selection, any farmer in Michigan has it in his power to markedly improve his corn variety.

10. Good seed corn can only be secured by selecting in the field from standing stalks, drying immediately and storing properly.

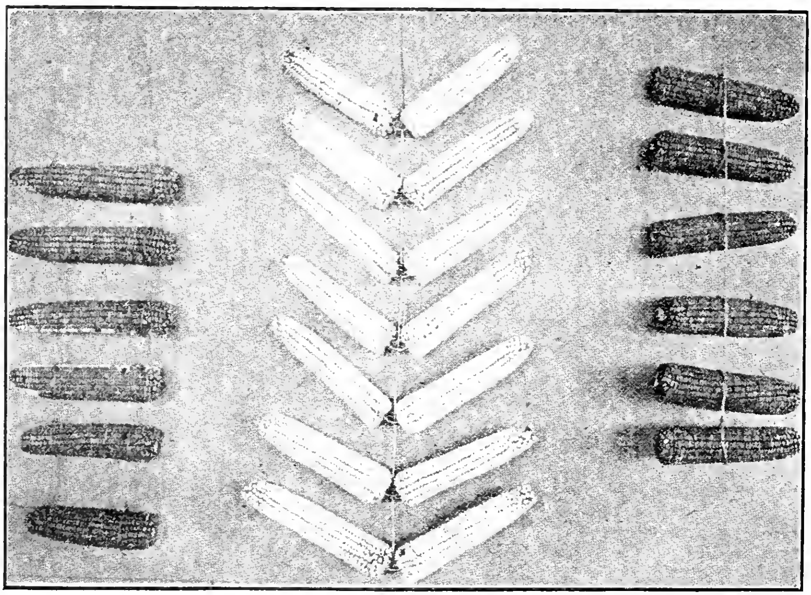
11. Selecting seed corn before cutting for silage.

Vigorous stalks carrying sufficiently matured ears are cut and shocked at edge of field. The ears are husked and cured for seed after standing in shock until kernels are sufficiently firm.

(Picture taken on farm of Jason Woodman, VanBuren County, Sept. 1919)

CURING AND STORING SEED CORN

Good seed corn can only be secured by thoroughly drying carefully selected ears before being exposed to freezing weather. In late September and during October, corn as it comes from the field contains from thirty to forty percent moisture. In this condition it is easily damaged by molding and freezing. In order to retain its vitality it must be rapidly dried so as to pass through the winter with a moisture content of twelve to fifteen percent.



12. Practical methods of drying seed corn. Free ventilation is necessary for rapid drying.

Immediately after harvest, corn for seed should be placed where it will receive free ventilation in order to dry rapidly. No two ears should be allowed to touch. Many excellent devices for drying and curing seed corn are in common use. The ears may be strung on binder twine and hung from a rafter. Wire racks on which the ears are impaled may be made from woven wire fences, or may be purchased. Racks may be easily constructed from two-by-fours and laths on which the ears may be laid. These racks should be placed in the attic or spare room in the house, tool room, etc. A well ventilated room is necessary. A cellar without furnace is as a rule a poor place to store seed corn. During the early period of drying all windows should be opened so as to remove excess moisture.

Corn properly dried will not be greatly damaged by freezing but it is best to store where it will not be exposed to extreme cold.

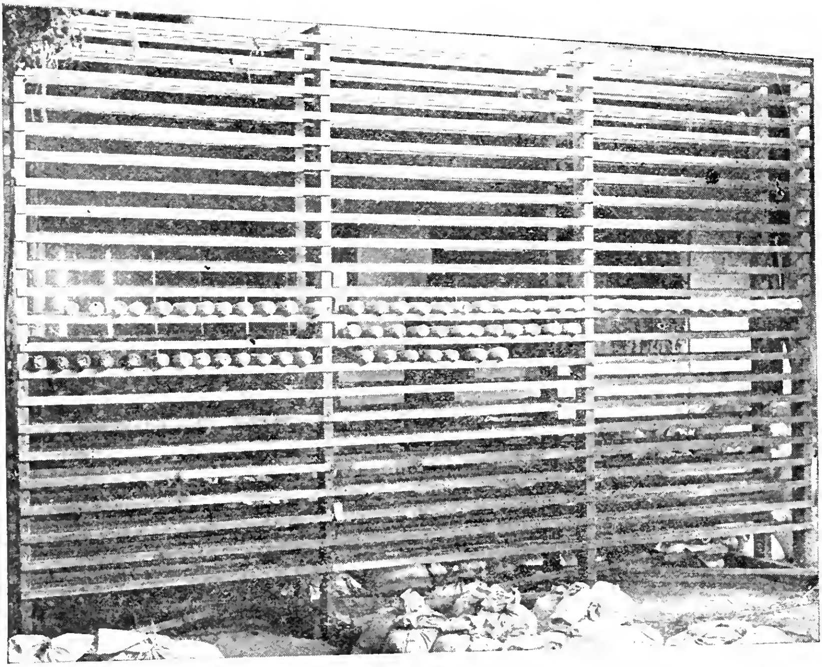
Where large amounts of seed are to be handled, special corn drying houses are desirable, equipped with numerous windows or panels which will give free circulation of air, and a stove to furnish artificial heat to hasten drying and prevent freezing.

SEED CORN DRYING HOUSE

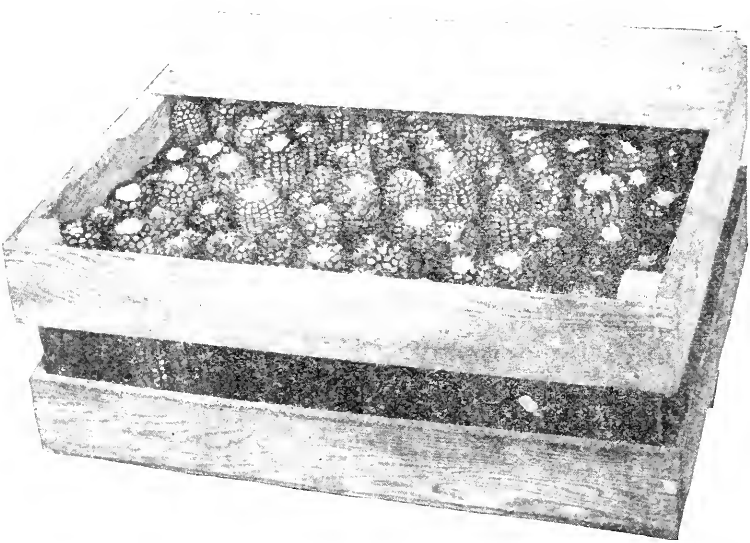
For the man who wishes to engage in the production of improved seed corn and its sale for seed year after year, a seed corn drying house is essential. In even the most unfavorable fall and winter seasons, corn may be properly dried and protected from freezing by the use of artificial heat used in connection with proper ventilation. A drying room or drying house, given over entirely to corn can be safe-guarded against mice and insects and will provide an excellent place for selection for improvement during the winter. Since it can be kept under lock and key, children and strangers will not disturb the work under way.

Such a drying house can be built at a cost of from $200 to $500 and will have a capacity of from 800 to 1000 bushels. During a season such as 1917, a corn drying house filled to capacity would have been paid for several times over in the resulting sale of properly cured seed. The drying house also furnishes a proper room for preparing corn for shipment, ear row work, keeping records, etc. It should be equipped with racks or hangers of a convenient type, should be provided with free ventilation and heated for at least three weeks after the corn is first hung with all ventilators open. During a cold snap, heat should be applied during the winter. The cheaper type of round bellied stoves, or an old stove that has been discarded will furnish sufficient heat.

A number of these corn drying houses, say five or more to each county in central and southern Michigan, will insure the planting each year in Michigan of seed corn of high germination. The best corn for Michigan, generally speaking, is native Michigan grown stock. For silage purposes in northern Michigan there are no better varieties than corn from central Michigan, and in central Michigan, either home grown stock or corn from southern Michigan, will prove best for silage. The men, who make it a business of growing seed and are properly equipped for curing and preparing for shipment, can be assured of profitable returns.



13. A seed corn rack, which insures proper curing, made from 2x4's and lath.



14. A seed corn Shipping Crate.

Corn shipped on the ear should be carried in crates which will provide free ventilation and protect from mice or rats. The space at side is screened with fly screen.

TESTING GERMINATION

"Test, don't guess" was first applied to corn by Mr. P. G. Holden, a native of Michigan, in pointing out the importance of testing the germination of each ear of corn to be planted. Careless methods of storing seed corn make it absolutely imperative that seed corn should be tested before planting.

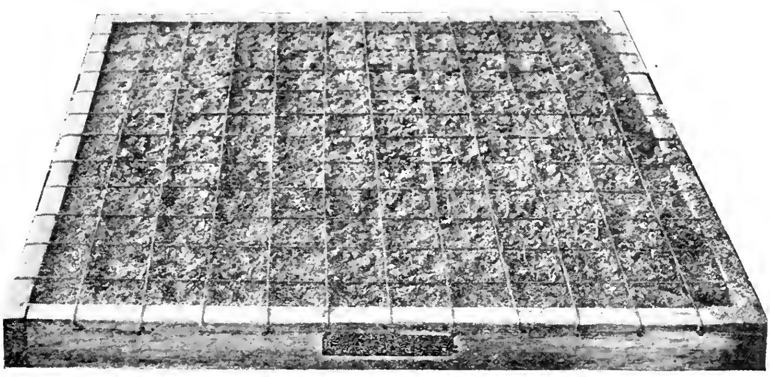
Experience has shown that it is impossible to surely distinguish, by outward appearance, or the knife blade test, between ears of good germination and ears of low vitality. The only accurate method is testing in the germinator. The sawdust box, sand box or rag doll tester, and special manufactured seed corn germinators are all efficient.

THE SAWDUST BOX TESTER

Construct square box 2 ft. by 2 ft., 3 inches deep. Cut piece of white cloth to fit and mark off in center with heavy lead pencil a square 20″ x 20″; divide into 100 squares 2″ x 2″. Number upper squares 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 at top, and left side row 1, 11, 21, 31, 41, 51, 61, 71, 81, 91.

Place one inch of sawdust moistened in warm water in bottom of box, pack firmly and smooth evenly. Moisten marked cloth and spread over sawdust on box.

Number ears to be tested and place where they will be undisturbed. Extract with penknife six kernels from each ear beginning near butt and turning ear slightly as each is extracted taking last near tip. Place kernels in square numbered to correspond with ear, germ face up, tips toward the bottom of box.



15. 100 ears can be tested at one time in the sand or earth box germinator, shown above. Six kernels from each numbered ear are planted, germ face up, tips down, in each square. The rows at edge of box are numbered 1, 2, 3, 4, 5. 6, 7, 8, 9, 10, and along top 9, 11, 21, 31, 41, 51, 61, 71 81, 91, thus indicating the number of each square. Numbers ranging from 1 to 10 are attached to ears to be tested, and kernels from each ear planted in square of corresponding number. The sand or earth is kept properly moistened and test is ready to read in from 10 to 14 days. Six strong sprouts in a square show desirable seed ears.

When all squares are filled, cover with moistened cloth 22″ x 22″. A third cloth or sack should be spread over box and 1½″ of moist sawdust spread evenly over top.

Place box in warm room in slightly inclined position so that the tips point down.

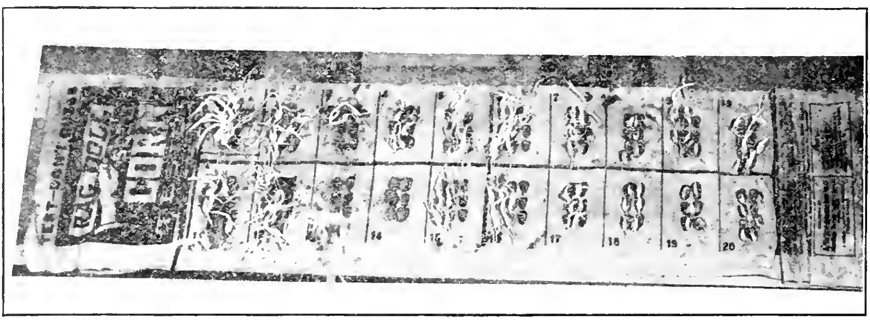
Inspect after several days and moisten if necessary. The test is ready to read in seven days. In taking test, roll back upper cloth, removing sawdust and carefully remove cloth over kernels.

Kernels from good ears should show vigorous sprout and root development. Kernels which fail to grow, or which produce weak sprouts, or moldy sprouts, come from ears unfit for seed and the ears corresponding to their numbers should be discarded.

THE RAG-DOLL TESTER

Cut cloth (cambric, muslin, or flannel) into strips five feet long and ten inches in width. Bisect lengthwise with heavy pencil line. Beginning about fifteen inches from end draw eleven cross lines at right angles to center line, three inches apart. Number spaces from one to ten on upper side of line and eleven to twenty on lower side.

Select and number ears to be tested. Dampen cloth and lay out smoothly on table. Remove six kernels from different parts of ear



16. The Rag Doll test is convenient and dependable.

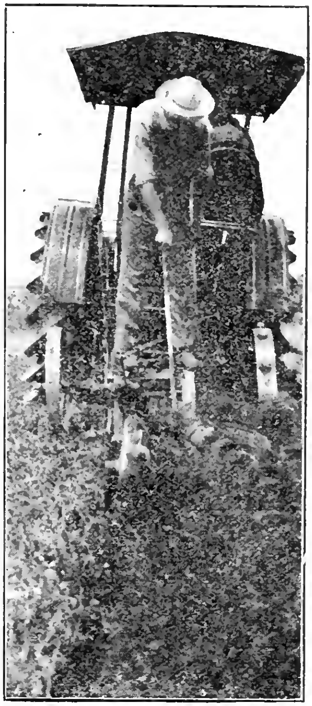
Kernels which show strong sprouts, free from mold or other fungous growth, indicate ears which are safe for seed purposes. Kernels, which fail to sprout or produce weak or moldy sprouts, indicate ears which should be discarded.

number one and place germ side up in space number one, tips pointing in same direction. Proceed with each ear in like manner. When spaces are filled roll carefully so as not to displace kernels and tie roll around center with string, place each roll as finished in bucket, cover with lukewarm water for several hours. Drain, and cover top with damp cloth or newspaper. Place in warm room. After several days moisten with warm water. On seventh day test is usually ready to read.

To read test unroll cloth carefully on table and study kernels in each square. Discard all ears corresponding to squares showing dead kernels which produced weak sprouts or mouldy sprouts. Save for planting ears with kernels showing strong, clean, stem and root sprouts.

COMPOSITE TEST

To test germination of shelled corn or to secure approximate condition of ear corn a composite test of 100 kernels should be made. In taking samples of ear corn, extract 100 kernels from each of 100 ears representative of entire lot. Place kernels in rag doll or sawdust box. After seven days count kernels which show strong germination. It will pay to ear test corn of less than 95% germination.



17. A good sod, plowed in fall or early spring makes an excellent foundation for a big corn crop.

THE CULTURE OF CORN

Corn thrives best on loams and clay loams, sufficiently drained, and well charged with organic matter and the mineral elements of fertility. It is not well adapted to light sandy soils or poorly drained soils. It is often possible by the addition of manure, the turning under of a green manuring crop, and applications of mineral fertilizers, to make light loams produce good crops of corn. It is also possible to drain poorly drained clay and muck areas and secure good yields from sufficiently early varieties, but the most profitable and successful crops result on fertile loams and clay loams, and it is on these soils that extensive corn production occurs and should be most largely encouraged.

18. Spring plowed land should be packed firmly with roller or cultipacker in order to firm lower part of furrow slice. After rolling, the ground should be disced or harrowed.

19. Thorough fitting of seed bed before planting corn greatly lessens labor of later cultivation

PREPARING CORN LAND

Fall plowing or early spring plowing to a depth of 7 inches or more, is the best beginning for a good seed bed for corn. Frequently the gain in crop yields resulting from early and deep plowing in fall or early spring, as compared to late spring plowing, is sufficient to more than offset the entire cost of plowing. Moisture is retained, the seed bed settles firmly, and insects are largely controlled when land is plowed in the fall.

Fall plowed land should be allowed to go through the winter in the rough, that is, as turned. In this shape it catches and holds snow and absorbs rain. As soon as in condition to be worked, fitting with disc, harrow or spring tooth should begin in the spring. Early spring plowing should be followed by roller and harrow.

The thorough fitting of the seed bed for corn saves labor in later cultivations, as well as increasing the yield. At intervals of ten days or two weeks either fall or spring plowed land should be harrowed or disced thoroughly, beginning as soon as ground can be worked in the spring. When fitting the seed bed weeds can be most economically controlled, and a great saving accomplished in the time and expense necessary in controlling weeds after planting the crop. Harrowing and discing before planting are much less costly methods of weed control than cultivating between the rows, and in these times of high labor-cost, thorough preparation before planting is an important step towards economy of production.

It is usual to plant corn after sod, applying manure before plowing. Sod land is generally more easily prepared in the fall and early spring. The early plowing gives time for the thorough incorporation of sod and manure with the soil. Corn planted on land prepared late in the spring is much more liable to injury from drought, insects, and weeds.

When it is necessary to plow late in the spring for corn, the ground should be very thoroughly rolled to compact firmly. The rolling should be followed by thorough and frequent discing and harrowing.

A good seed bed for corn should be well settled at the bottom of the furrow slice and as approaching the condition known as "garden tilth" as nearly as possible at the surface.

FERTILIZING THE CORN CROP

Corn makes excellent use of manure. Applications previous to plowing or when fitting the land of 6 to 8 tons of manure are followed by a marked increase in yield. The use of acid phosphate, or a fertilizer high in phosphorus, in connection with manure, results in further increasing the yield and noticeably hastens maturity. The application of 200 to 300 lbs. of acid phosphate or of a commercial fertilizer high in phosphorus, is recommended.

On light or badly run land, a complete fertilizer such as a 2-10-2 or a 2-8-2, carrying nitrogen, phosphorus, and potash may give good returns.

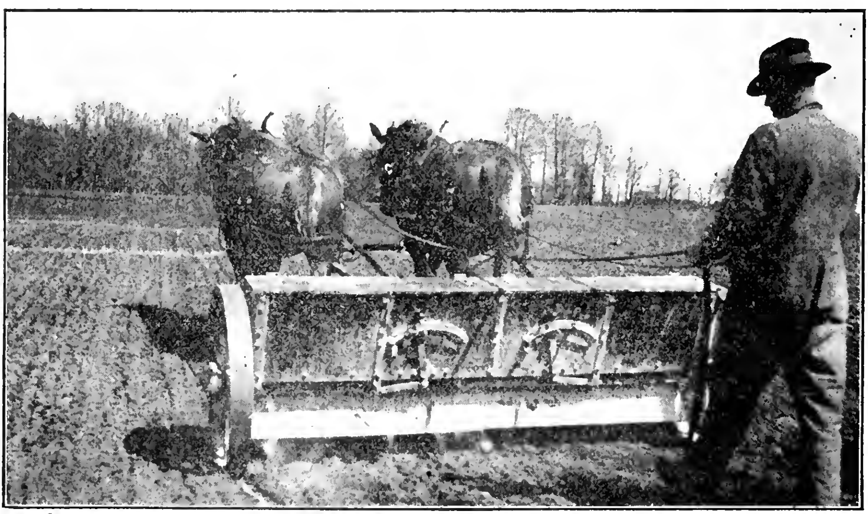
On muck soils fertilizers high in potash and phosphorus are necessary for continued success with corn.

Best results are secured from fertilizer by applying broadcast when fitting seed bed. An amount of more than 150 lbs. per acre, drilled in the rows, may cause concentration of corn roots close under the hill, or injure sprouting seed, thus leaving the crop in poor condition to withstand periods of drought. On light soil, when planting late under dry conditions, the use of not more than half this amount may be advisable.[1]

YIELDS PER ACRE OF MANURED CORN IN A CORN, WHEAT, AND CLOVER ROTATION, 1911-1916

Treatment per acre.	1911.	1912.	1913.	1914.	1915.	1916.	Average for 6 years.
No manure or fertilizer	38.5	41.3	46.8	20.3	32.0	20.0	33.2
5 tons yard manure	45.7	46.3	51.0	38.1	40.9	26.1	42.4
5 tons stall manure	45.7	46.3	56.6	38.1	43.0	26.2	42.7
5 tons stall manure, 200 lbs. acid phosphate	57.0	48.4	60.8	46.7	47.4	32.0	48.7
5 tons stall manure, 200 lbs. floats	51.0	49.3	57.2	48.2	43.0	28.4	46.2
10 tons stall manure	52.0	48.5	65.7	51.6	48.8	28.7	49.2

The foregoing results from rotation and fertilizer experiments at the Michigan Agricultural College, covering a period of six years are reported by Professor V. M. Shoesmith in the annual report of the State Board of Agriculture for 1917, Farm Crops Division:



20. Acid Phosphate, other commercial fertilizers, or lime are most conveniently applied at time of fitting the seed bed. An application of from 200 to 250 pounds of Acid Phosphate usually gives marked increase in yields of corn and hastens maturity.

1. For further information relative to use and application of commercial fertilizers, refer to Regular Bulletins No. 290 Soil Fertility; and No. 284, Some Information and Suggestions concerning the use of Phosphorus,—by this station.

PLANTING CORN

The most favorable time to plant corn varies with the latitude, altitude, soil and drainage condition, and location with reference to large bodies of water. In southern Michigan the average range of the best period for planting is from May 1st to 20th; in central Michigan counties May 10th to 25th; and in the northern part of the Lower Peninsula and in the Upper Peninsula May 20th to June 5th. In general, early plantings within the periods named are advisable. In exceptionally early seasons corn can be planted safely at an earlier date than given above and in extremely late seasons the planting time may be delayed to a later date than indicated.

The best time to plant corn varies also with individual seasons; hence, the old sign of the Indians for a safe planting time—"when the leaves of the White Oak are the size of squirrel's ears"—can be taken as an excellent guide. Long years of observation have proven the dependability of this Indian sign.

Rate of Planting:

The advisable rate of planting depends on length of growing season and fertility of soil. In southern Michigan counties on fertile corn ground the usual method is to plant in hills 42 to 44 inches apart, dropping three kernels per hill or drilled in rows 42 to 44 inches apart dropping a kernel every 14 inches. On lighter soils of the extreme southern counties it is usual to plant 2 kernels per hill 44 inches apart.

21. Corn starts best on a well surfaced seed bed with furrow slice well settled.

In central Michigan the usual distance between hills is 38 to 42 inches, dropping 3 kernels per hill or planting in rows 38 or 42 inches apart with a kernel every 12 to 14 inches.

In northern Michigan, sections 3 and 4, corn is usually planted in hills 3 or 4 kernels per hill, 36 to 38 inches apart. The varieties are smaller and seed can be planted thicker.

For silage the rates above mentioned may be used if part of the field is to be handled for grain. Somewhat thicker planting, drilling in rows 36 to 42 inches apart with kernels every 10 inches apart, will increase the tonnage.

For grain purposes from 4 to 5 quarts per acre is sufficient, and for silage purposes the rate of planting ranges from 5 to 8 quarts per acre.

The depth of planting corn varies with the soil. On well drained loams $1\frac{1}{2}$ to $2\frac{1}{2}$ inches is the proper depth and on heavy clay or clay loams 1 to 2 inches.

CULTIVATING CORN

It is an excellent practice to harrow immediately after planting with smoothing harrow. On heavy land it is safe to use a spike tooth harrow, with teeth set slanting, until the corn appears above the ground. The weeder may be employed until the corn is 6 to 8 inches in height. The first cultivation with the corn cultivator may be made as soon as the corn is high enough so that the rows can be easily followed. This cultivation should be deep, at least 4 or 5 inches and close to the rows. The second cultivation should come from 5 to 8 days later, and should not be quite so deep. Throwing dirt to the plants when making early

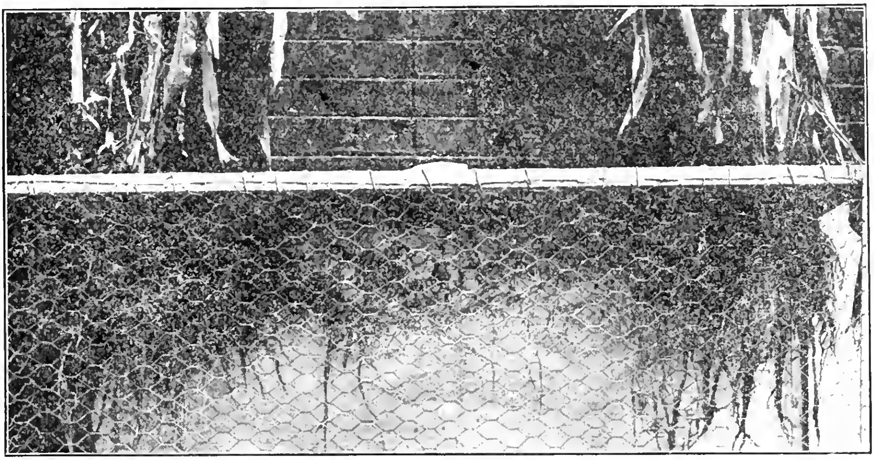
22. Frequent shallow cultivations are necessary to control weeds and keep surface in good tilth.

cultivations, covers and kills small weeds in row. The following cultivations should be made at intervals of one week to ten days, and should be shallow, not going to more than 3 inches in depth. Care should be taken not to approach too near the corn plants, in later cultivations, thus causing injury through pruning feeding roots. It should be kept in mind that after a period of 35 to 40 days' growth, the roots of the corn plant interlace between the rows, and closely approaching the surface, filling the space between the hills with a dense net-work of fine feeding roots. Cultivation deeper than 2 or 3 inches or too close to the plant at this time will cut these important feeding roots, and cause a decrease in yield.

From four to six cultivations are usual, depending on the season. Additional cultivations generally give a slight increase in yield, but too

many cultivations may cost more than the increase in yield will pay for. The number of cultivations necessary will depend on the season and the condition of the land. It is imperative that cultivation be sufficiently frequent to effectively control weed growth. Thorough preparation before planting will lessen the number of cultivations necessary as compared to land not so well fitted.

Cultivators carrying numerous small shovels or blades, designed to accomplish thorough surface cultivation, have rapidly displaced the old type of corn cultivators carrying larger and fewer shovels.



23. After forty days' growth corn roots interlace between the rows close to the surface. Shallow cultivation is advisable to prevent pruning of surface feeding roots.

HARVESTING CORN FOR GRAIN

Corn is ready to harvest when fully mature or when growth is stopped by heavy frost. In Michigan the usual method is to cut and shock, husking later from the shock and storing in cribs.

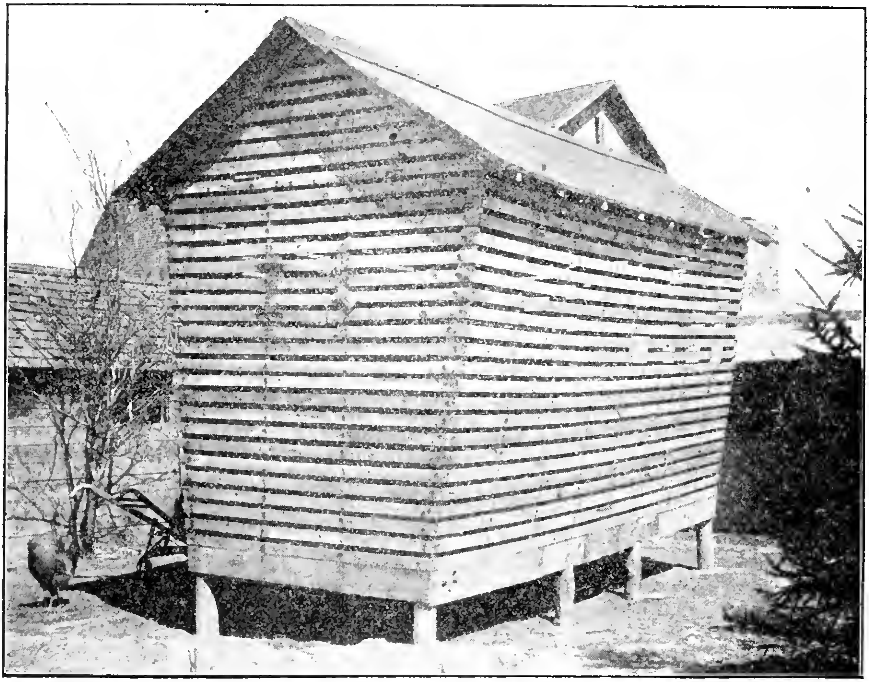
Under average conditions, the moisture content in Michigan corn, at the time of harvest, ranges from 25 to as high as 40%. It is, therefore, advisable to store in cribs properly constructed to offer proper ventilation. The cribs should be made narrow, or if broad, should be provided with central ventilation, made of properly spaced boards or of wire attached to frames.

The accompanying picture No. 24, shows crib, constructed by Dean R. S. Shaw of the Michigan Agricultural College, for storing ear corn. This crib has given excellent service during years when ear corn was high in moisture content.

HARVESTING FOR SILAGE

It has been estimated that from 40 to 50% of Michigan's corn crop goes into the silo. In many counties of northern Michigan 90% of the corn crop is grown for silage purposes. The widespread use of the silo has carried corn growing to many counties in northern Michigan. During years of early fall frosts the presence of a great number of silos insures the safety and the proper harvest and most economical use of a

great part of the crop. The individual can secure excellent insurance against loss of feed due to early frosts by providing sufficient silo capacity. The building of more silos throughout the state tends to increase the importance and dependability of the corn crop.



24. A practical and Economical Type of Corn Crib.

Storage cribs should be built with properly spaced siding and sufficiently narrow to provide proper ventilation. If the corn is exceedingly high in moisture, ventilators should be constructed with board strips on two-by-fours, or wire mesh partitions down center of crib.

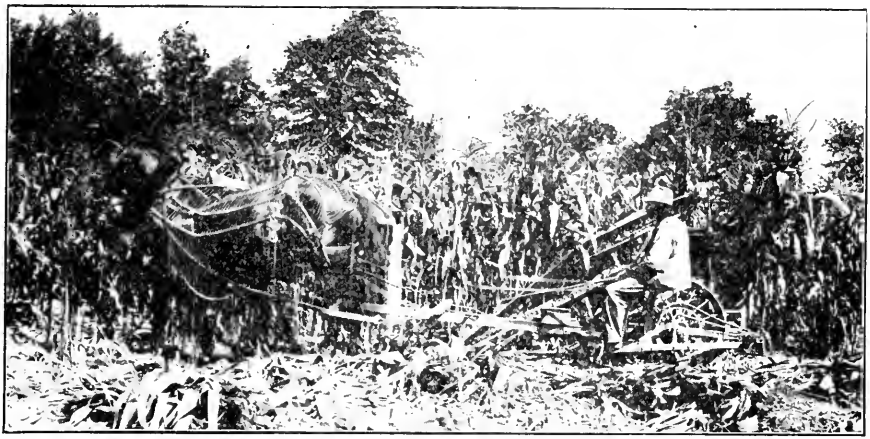
Photograph taken on farm of Dean R. S. Shaw, East Lansing. This crib is 8 ft x 16 ft and 8 ft high at post. It was built in 1919 at a cost for material of $60.95. The capacity 700 to 800 bushels.

The best time to cut corn for ensilage is when the crop has practically matured but retains enough moisture to make succulent silage. At this stage the kernels are dented and glazed, and the lower leaves of the plant are brown. Almost two-thirds of the food value of the mature corn plant is in the ear, hence it is desirable that a good ear development, as well as a vigorous growth of stalk, be produced.

NO. 4. YIELD OF DIGESTIBLE MATTER IN CORN

Constituent.	Yield per acre.		
	Ears.	Stover.	Total crop.
	Pounds.	*Pounds.*	*Pounds.*
Protein	244	83	327
Carbohydrates	2,301	1,473	3,774
Fat	125	22	147
Total	2,670	1,578	4,248

The foregoing table (No. 4) from Farmers' Bulletin No. 578, U. S. D. A., shows the yield of digestible matter in the ear and in the stalk of the corn plant.



25. From forty to fifty per cent of Michigan's corn crop goes into the silo. Varieties which reach the dented and glazed kernel stage of maturity make the best quality of ensilage.

NO. 5. CHEMICAL CHANGES DURING GROWTH OF CORN PLANT

Yield per acre.	Tasseled July 30.	Silked Aug. 9.	Milk Aug. 21.	Glazed Sept. 7.	Ripe Sept. 23.
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Total yield	18,045	25,745	32,600	32,295	28,460
Water	16,426	22,666	27,957	25,093	20,542
Dry matter	1,619	3,078	4,643	7,202	7,918
Ash	138.91	201.30	232.15	302.48	364.23
Albuminoids	239.77	436.76	478.69	643.86	677.78
Crude fiber	514.19	872.93	1,261.97	1,755.85	1,734.04
Nitrogen-free extract	653.91	1,399.26	2,441.29	4,239.82	4,827.60
Fat	72.20	167.75	228.90	259.99	314.34

Table No. 5—From Farmers' Bulletin No. 578, U. S. D. A., showing the chemical changes during the growth of the corn plant. The study of this table brings out the fact that the greatest weight per acre of food material is produced when kernels are glazed or fully matured. The best silage is made when corn is cut when the kernels are glazed and dented, and while the stalk and ear carry sufficient moisture to make succulent silage.

When corn is injured by heavy frost it should immediately be put into the silo to prevent rapid drying out. When corn has lost too much water, due to over maturity, or after freezing, to make succulent silage, water in sufficient amounts should be added when the silo is filled.

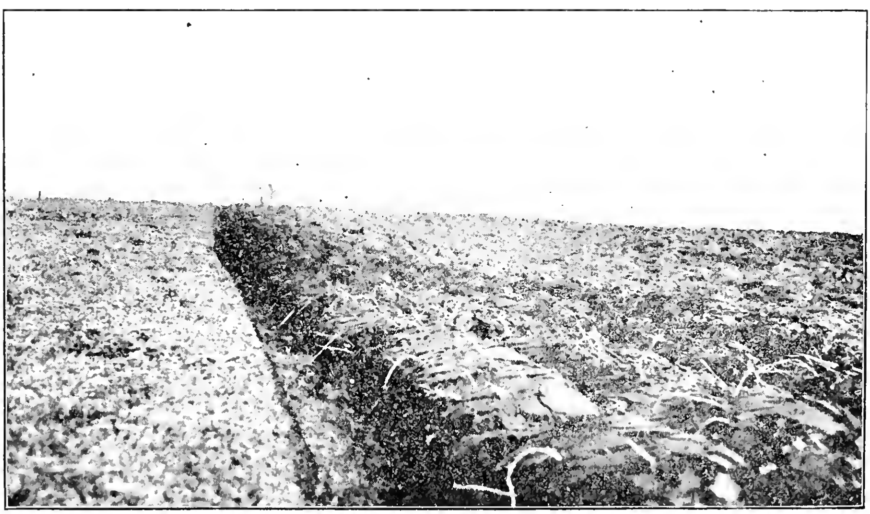
The practice of snapping the ears from the corn and making silage of stover, reduces the feeding value of the silage. This method may be a convenient way to handle stover where ear corn is used to feed hogs or other stock, but it cannot be expected that silage made from stover will produce as good gains with livestock as silage made from stalks carrying the ear. Stover silage is a cheap form of roughage for carrying breeding stock or feeders over winter, but is not advised for feeding dairy stock for production or for fattening beef animals.

Good fields of silage corn will yield from 12 to 16 tons of silage material per acre.

HOGGING DOWN CORN

Hogging down, or pasturing off, corn with hogs is a practice which has gained rapidly in lower Michigan counties during the past few years of labor scarcity. It has been proven by numerous experiments that this method of harvesting corn is economical in saving labor of harvesting and of feeding, and also from the standpoint of the gain and weight of hogs being fattened. The manure produced, is left directly on the ground, thus benefiting the land and preventing a waste of fertility. Corn may be pastured in the field with sheep in the same manner.

One man can handle a larger acreage of corn and feed out more hogs under this system than by other methods. The hogs should not be allowed to cover too much ground at one time. A good practice is to fence off the part of the field to be hogged down by use of a 2 ft. woven wire fence, held by anchor posts at either side of the field and supported by occasional posts or tied with binder twine to hills of corn. Hogs should be turned in when corn is in the hard dough or almost mature stage.



26. Alfalfa paves the way for big yields of corn.

All or part of the field may be hogged down. Four to eight acres can be fenced off at a time. When the area is cleaned up, fences should be moved to include an equal area of standing corn.

Under average conditions, in corn yielding 40 bushels or 80 baskets per acre, 4 to 6 hogs can be carried per acre. Heavier yields will carry more hogs. It will take 6 to 8 weeks for four or six hogs to clean up an acre of good corn.

It is advisable to plant rape, rye, or soybeans with corn which is to be hogged down. Rape should be planted at the rate of two pounds per acre of Dwarf Essex Rape at the last cultivation and rye at the rate of one bushel per acre at the last cultivation. A mixture of the rape and rye is often more effective for late fall pasture than either seeded alone. Rye and vetch, at rates of 1 bushel of rye to 20 pounds of hairy vetch, is another excellent seeding to be made with corn at the last cultivation.

Six or eight pounds of soy beans, drilled in with planter attachment or immediately after corn is planted, furnish additional forage for hogs.

Rye can be grown separately to furnish an early grain for hogging off.

Professor G. A. Brown of the Department of Animal Husbandry suggests that a protein supplementary ration be fed in cases where rape, rye or soy beans fail. In addition to the corn being hogged off, he suggests the feeding of skim milk or tankage.

CORN IN ROTATION

The corn crop is well suited to Michigan's cropping systems in all sections where it is adapted. Corn is an excellent crop to grow after meadow or pasture crops. The plant has been described as a "rough feeder," owing to the fact that it can apparently make the best use of organic matter, such as sod and manure which has not yet become thoroughly incorporated with the soil. It is a crop which requires thorough cultivation; hence, offers excellent opportunity for the control of weeds and grass after a sod. Preparation of the land for corn, and the cultivation given the crop, leave the ground in excellent condition for a following crop of small grain.

Growing corn in rotation aids in maintaining fertility and prevents extreme loss from insect pests or diseases. Corn smut does most damage where corn follows corn for a number of years. Growing corn in rotation with other crops is the only effective means of keeping this disease in control. Occasionally considerable damage is done to corn, when planted after an old sod, by the grubs or larvae of the June Beetle. Early plowing and thorough working will minimize such loss. Fall plowing is particularly effective. A newly turned meadow or pasture sod will pave the way for a large corn crop.

The usual rotations including corn are the following:

1. Three year rotation: the first year, clover or meadow; second year, corn; third year, small grains seeded to clover.
2. Four year rotation: first year clover; second year, corn; third year, oats, and fourth year, wheat seeded to clover.
3. Four year rotation including beans, and beets: first year, clover; second year, corn, beans or beets; third year beans, beets or corn; and fourth year oats seeded.
4. Five year rotation including timothy, and clover meadow: first

year, clover and timothy meadow; second year, corn; third year, oats seeded to clover and timothy; fourth year, clover and timothy; fifth year, timothy and clover.

5. Six year rotation including beans or beets: first year, clover; second year, corn, beets or beans; third year, oats; fourth year, clover; fifth year, beans, beets or corn, and sixth year, wheat seeded with clover.

6. Alfalfa 3 to 5 years, corn, corn, barley or oats seeded.

Rotation 1, 2, and 3 are most frequent in southern and central Michigan.

In bean and beet regions 4 and 5 are often followed. Rotation No. 5 is particularly effective in the up-keep of organic matter since a clover crop occurs every third year.

An alfalfa sod furnishes excellent condition for corn, and owing to the success with which this crop is being seeded, the more general use of rotations including alfalfa is highly desired.

CORN SMUT

In view of the prevalence of corn smut and the importance of controlling this disease, the following discussion has been prepared by Dr. G. H. Coons, Plant Pathologist of the Michigan Experiment Station:

IS BEST CONTROLLED BY ROTATION

Every year at harvest time, inquiries come as to the cause and control of corn smut. This is a fungous disease related to, but entirely distinct from the smut diseases known for other crop plants,—wheat, oats, and barley. The smut affects the corn at almost any growing part, the stem, the leaf, the ear, the husk, the silk or the tassel, producing a swelling which is at first white then greenish black. The attack of corn smut may come at any time of the season when corn is growing, the newly formed tender parts being most subject to it.

Typically the corn smut fungus lives over winter in the old stalks in the field. These live, infectious spores in the spring are blown by the wind to the young corn. A close examination of corn about a foot high will reveal a plant here and there with whitish over-growths,—the so-called smut boils. Only a few of these are formed, but they mature their spores and furnish the source of the later infections. Over and over again the story is repeated until the corn shows in the fall a liberal amount of this wasting disease.

The control measures for corn smut depend upon the nature of the smut's life history. Since infection takes place throughout the season, this disease cannot be prevented as is oat smut or wheat stinking smut, by seed treatment. In short, any recommendation to dip seed for control of corn smut is unwarranted.

Since the source of smut in early summer is largely the old smutted stalks of last year's crop, the planting of corn to follow corn augments most seriously the amount of smut infection. Experience in Michigan with field corn has indicated that with the ordinary season rotation is

enough to prevent excessive loss from smut, but occasional occurrence arising from spores blown from near-by fields must be expected.

With a crop grown intensively, such as sweet corn or special lots of seed corn, rogueing of smutted plants early in the season is certainly to be advised. This with rotation will prevent loss. With corn as a field crop the pulling and destroying by fire of any smutted or deformed plants seen during cultivation is advisable. It is not known whether it will be practical to attempt to further eradicate the early infections by field inspections, etc. Whatever is done, harvest must come early in the season before the smut growth gets powdery.

Farmers, therefore, must not rely on seed treatment for corn. Instead they must see in rotation of crops their best ally in the battle with a wasting plant disease. The hope of the future lies in the securing of smut resistant sorts, but as yet none of these are known or tested for Michigan conditions.

27. Growing corn in a proper rotation is the most effective means of controlling corn smut.

CORN IMPROVEMENT THROUGH INTENSIFIED SELECTION

THE EAR ROW TEST AND REMNANT SYSTEM

Corn is an extremely adaptable plant in the hands of the experienced breeder. Only a few hundred years ago this crop was grown only by the American Indian. Judged by specimens preserved in burial mounds, and by varieties found in the hands of the Indians by incoming settlers, corn, as the Indians knew it, was much smaller eared and of inferior types as compared to present standards. In the hands of the white man, hundreds of varieties have been created to suit new conditions and uses.

Possibilities in corn improvement have by no means been fully realized, in spite of the great strides which have been made in corn development by careful field selection. It has long been known that individual

28. Ear row test of Duncan corn, 100 ear unit. (M. A. C. Experiment Station 1919.)

ears of corn differ markedly in their productive power, maturity, character of growth, etc., but owing to the fact that corn is open or cross pollinated under field conditions, improvement by selection is comparatively slow.

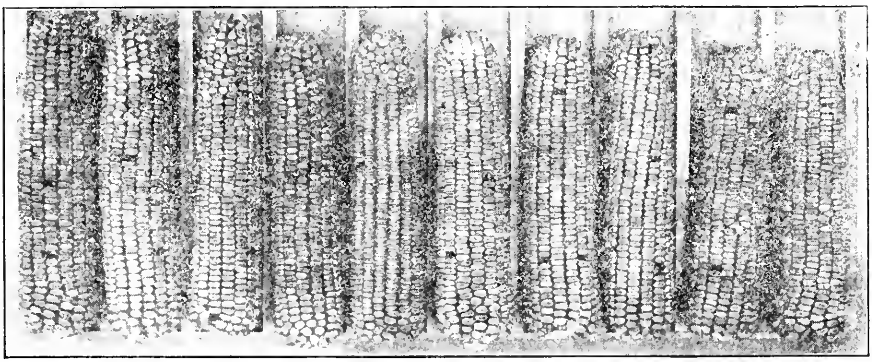
More rapid results can be secured by the ear row test and the remnant system of intensified selection. Briefly stated, this method consists in planting 50 hills or more in marked rows, properly checked, from each of 100 or more carefully selected ears, the ears being shelled lengthwise, and half of the ear reserved. The adaptation and yielding ability of the ears are found in the ear row test. The remnant ears from several of the highest yielders are planted the second year in an increase plat and multiplied for general distribution.

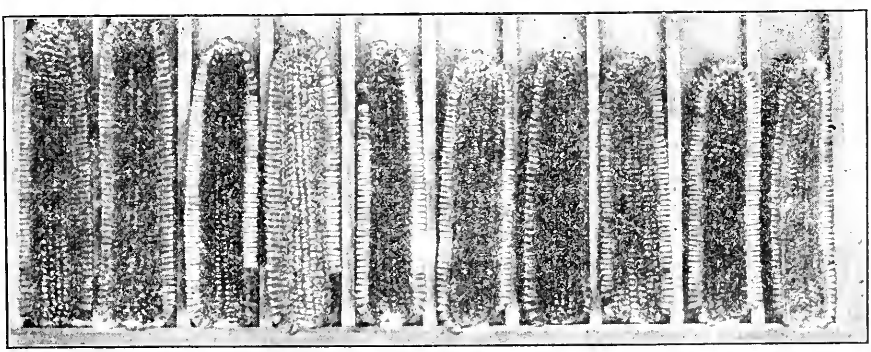
For the practical corn breeder who wishes more rapid results than come from simple field selection the following method is suggested:

1. Select in field at time of maturity, 5 bushels or more of ears from a variety of known worth, and store ears properly.

2. In late winter or early spring carefully select 100 or more ears of the best type and test for germination.

3. Select at least 40 ears of high germination and superior type for planting in ear row test.





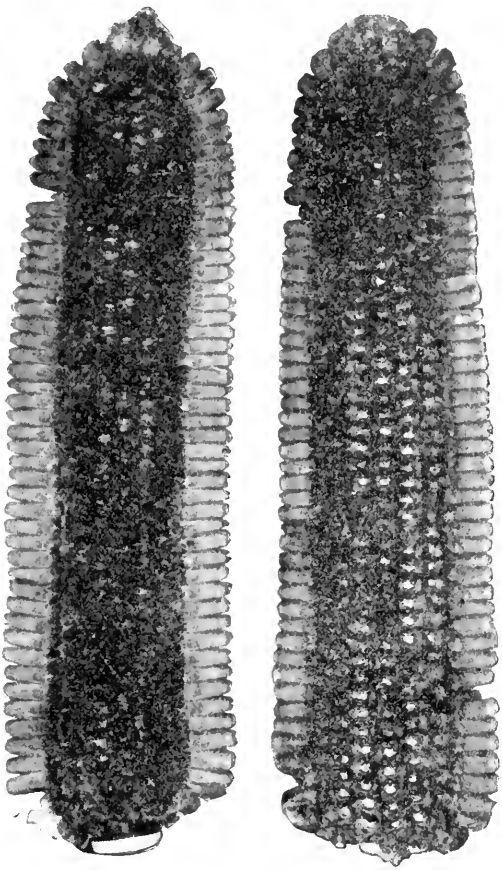
29. Ears of good maturity, type, and adaptation should be selected for ear row test work. These ears are then tested for germination and shelled lengthwise, the kernels which are shelled being used in making ear row test and remnants being reserved for selection and planting of those shown best by test. Half of ear reserved.

30. Corn Selfing Plat—Michigan Agricultural College. Professor F. A. Spragg is selfing the best plants from ear-to-row breeding work in the effort to markedly improve Michigan corn varieties by this method.

31. Remnant ears from ear row test wrapped in paper and enclosed in wire screen bag in order to protect them from mice and insects until leading ears are ascertained by test and selected for second year's use.

4. Shell half the kernels from each ear lengthwise. Place in envelope, numbered to correspond with number of ear on tag, pinned to butt or tied to ear.

5. Place unshelled half of ears carefully on rack, or protect by wrapping in paper and placing in bag made of screen mesh to exclude rodents and insects until needed the next year.



32. Appearance of individual ears no sure indication of yield.

Ear No. 966 on left yield of 74.86 bushels per acre and ear No. 974 on right, 49.86 bushels per acre.

The yield in ear row test from kernels from each of these ears is shown in cuts 32 and 33. The ear row test shows the difference in yielding ability of individual ears.

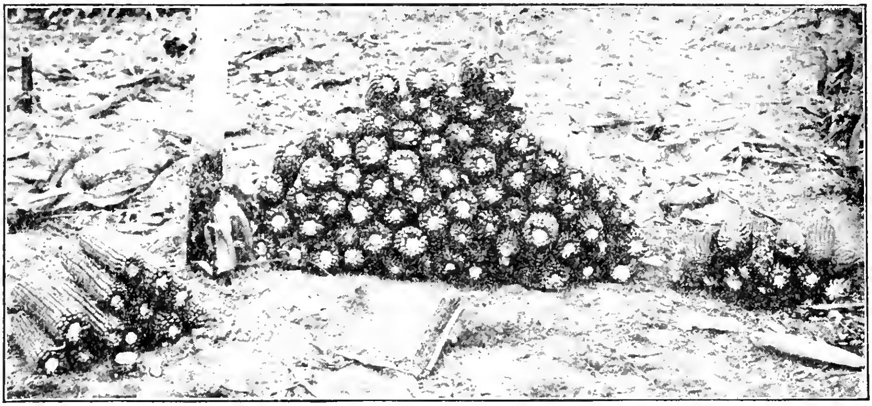
6. Plant in ear row test, using seed in envelope. Select uniform soil and plant seed from each individual ear in rows 50 hills or more long, with check every 4th row planted to tested seed of the same variety.

7. Mark each row with stake with number to correspond with ear from which seed was taken.

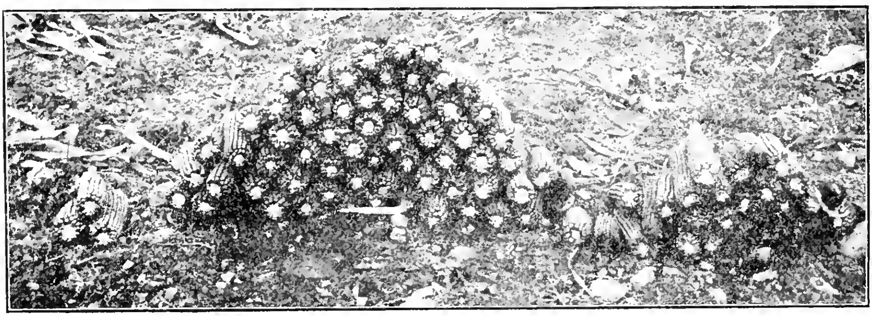
8. Give thorough cultivation, noting carefully growth from seed from every half ear.

9. Harvest each row separately, weighing up stalks and ears. Careful notes should be taken of the total yield, maturity of ears and percent of marketable corn.

10. When several of the highest yielding and most desirable rows are ascertained, the remnants or half ears, placed on the shelf the year before, corresponding to the numbers picked out, are separated from the remainder of the remnants.



33. No. 966 row, highest yield. Note high per cent merchantable ears at center, and early maturing ears on left.



34. No. 974 row in Duncan Ear Row Plat 1919. Note high per cent of nubbins on right and small number of early maturing ears on left. Production of high and low yielding individual ears.

Plants from No. 966 yielded at the rate of 74.86 bushels per acre with 81% marketable ears and a large number of early maturing ears.
Plants from No. 974 yielded at the rate of 46.89 bushels per acre with only 70% of marketable ears and a small per cent of early maturing ears.

11. Plant the increase plat the second year from seed shelled off of the highest yielding ears. This increase plat would be well removed from other corn fields to prevent cross-pollination. Usually one or two quarts of seed are available from the leaders. The increase plat may be planted in a large potato or bean field, corner of grain field, or where protected by woods or barn from danger of cross-pollination from other corn.

12. Field select seed from increase plat in the fall. From four to ten bushels of selected seed corn should result. This will provide for a substantial planting of 20 acres or more the third season.

13. Selection may be intensified by picking out 20 or 30 of the best ears from the increase plat and planting in marked area for the third year's increase field. Selections for further ear-row work or increase work can then be made from this marked area.

The yield, adaptation, and type of corn can be greatly improved by this intensified method of selection.

Plant breeders are securing promising results by self-pollinating the corn plant to secure pure lines and recombining desirable strains so secured. As yet, no varieties of widespread note have been given to farmers by this method, though in the future valuable strains may be developed.

EAR ROW RESULTS SHOWING VARIATIONS

EXPERIMENT STATION PLAT, 1919

As an example of variations in yield and maturity brought out by ear row work, the following table of data on eight of 75 ears included in M. A. C. ear row work of 1919 is offered:

Row Number.	Early matured Ears.	Market Quality.	Moisture in per cent.	Grain per cent.	Bushels per acre, 14% moisture.
Average of checks	2.4	71 3	342	853	49.89
9.10	15	*63 9	*37.1	853	*62.42
9.12	*28	76 9	*317	86	52.31
9 28	*0	71	358	871	36.48
9.32	12	*82	345	878	53.47
9 36	8	78	322	*889	42.30
9 11	6	75 9	342	*837	*32.52
*9.66	12	81	31	87	74.86
*9.74	3	70	321	867	46.89
*9.66	12	81	31	87	74.86
*9.74	3	70	321	867	46.89

*Row No. 9.10 shows highest yield but is too late in maturing.

*Row No. 9.12 shows consistency for early maturing with yield slightly above average of checks.

*Row No. 9.28—lateness of maturity but not high yield.

*Row No. 9.32—shows an average ear in market quality.

*Row No. 9.36 shows high selling percent but not high yielding ability.

Row No. 9.11 shows low shelling percent and low yielding ability, but not necessarily very early.

*Row No. 9.66 shows highest yield in plat and uniform excellence in other desirable characters. Note plate.

*Row No. 9.74 shows low yield lack of early maturity high percent of nubbins compared with No. 66. Note plate.

35. Individual rows in ear row test plat shocked for harvest—(M. A. C. Exp. Sta. 1919). This method is being employed in improving the Duncan, Golden Glow and Early Silver King and other varieties. Selected strains are distributed through the Crop Improvement Association.

CORN EXHIBITS

Corn exhibits have played a valuable part in the development and spread of corn varieties. These occasions bring together representative varieties, and the proper placing of prizes calls attention to those which are best adapted and best suited for seed purposes. Corn growers are given the opportunity of an interchange of ideas, and the attention of the general public is directed toward the importance of the corn crop. Interest on the part of the corn grower is stimulated in the inspirational atmosphere of a successful corn exhibit.

These exhibits are usually held by Farm Bureaus, Farmers' Clubs, Boys and Girls Clubs, and at county and state fairs.

For those not familiar with the methods of conducting a corn exhibit the following classification and list of premiums is presented:

CLASSIFICATION OF CORN EXHIBIT AND LIST OF PREMIUMS

Note: The premiums suggested are larger than are usually offered. It is suggested that such amounts as are available be awarded in proportions indicated.

Class 1. 10 ears Yellow Dent—first, \$5.00; second, \$3.00; third, \$2.00; fourth, \$1.00. Award of merit to next six entries, ribbon or card.

Class 2. 10 ears of White Dent—same awards.

Class 3. 10 ears of White Cap—same awards.

Class 4. 10 ears of any other Dent corn—1st, \$4.00; 2nd, \$3.00; 3rd, \$2.00, 4th, \$1.00.

Class 5. Any special prizes which may be awarded for best 10 ears.

Class 6. 100 ears of any variety of corn—first, \$10.00; second, \$7.50; third, \$5.00; fourth, \$2.50. Award of merit for the next six.

Class 7. 10 ears of Flint Corn—first, $4.00; second, $3.00; third, $2.00; fourth, $1.00.

Class 8. 10 ears of pop corn (rice)—same awards.

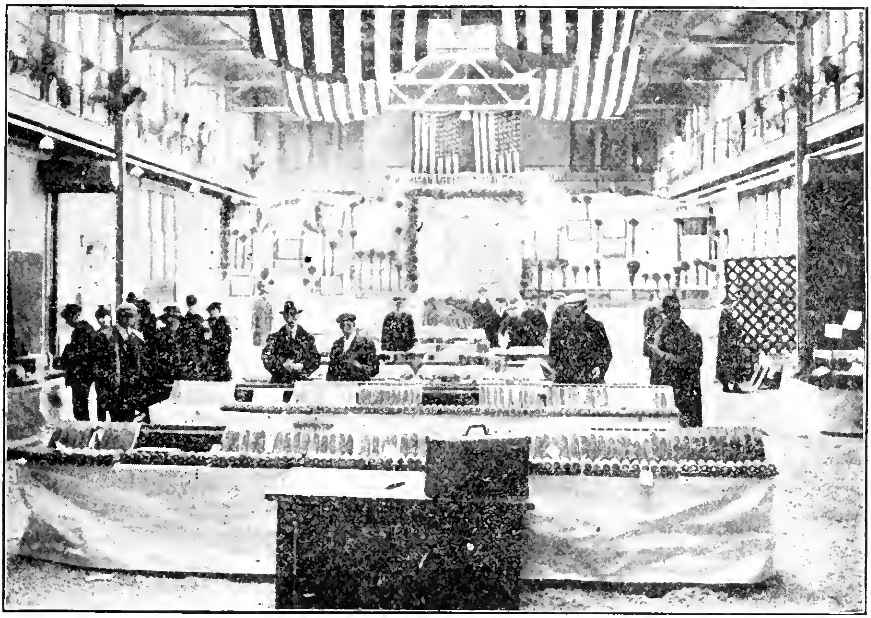
Class 9. 10 ears of pop corn (pearl)—same awards.

Class 10. 10 ears of sweet corn (table)—same awards.

Class 11. 10 ears of sweet corn (canning)—same awards.

Class 12. Sweepstakes. Best 10 ears of Dent corn.
(Leading Variety of County).

Class 13. Best single ear of (Standard) Variety—first, $5.00; second, $4.00; third, $3.00; fourth, $2.00.



36. A good corn exhibit calls attention to best adapted varieties and stimulates and inspires interest in corn production.

FOREST PLANTING IN MICHIGAN

Special Bulletin 103

By A. K. CHITTENDEN—FORESTRY SECTION

In establishing a forest plantation the landowner should know what trees are best suited to the locality and soil and which of these trees will best serve the objects he has in mind. Trees grow slowly as compared with other crops and it takes many years for them to reach maturity or sufficient size for utilization. Mistakes made in planting may become apparent only after many years, and owing to such mistakes the objects for which the plantation was established may not be attained. It is with the purpose of helping landowners to select and properly plant trees suited to their purpose that this bulletin has been written.

Forest plantations are established for one or more of several reasons. The commonest are to produce fence posts, timber or lumber, to act as a windbreak or shelter, to hold shifting sand, to prevent erosion or gullying, and to beautify the landscape.

In general it does not pay to raise trees for timber purposes on good agricultural soil. Such land will produce more money from farm crops. A woodlot is, however, a valuable adjunct to a farm, and many farm woodlots which are on agricultural soil are valuable assets. Forest plantations are usually advisable on parts of farms which are rough or rocky, or where the soil is so poor as to be unsuited for farm crops. Forest planting is often advisable in already existing woodlots where openings have occurred which are not restocking naturally or where it is desired to introduce new species of trees. The planting of trees for windbreaks or screens is advisable on many farms. Forest planting is also advisable on very large areas of cut-over lands and on more or less barren lands, such as the jack pine plains where, in many places, trees are the only crop that can be successfully grown.

TIME TO PLANT

Trees should be planted while they are dormant. They may be planted in the spring as soon as the frost is out of the ground until the trees start growth or, in the case of hardwoods, and rarely of conifers, in the fall. Trees should not be planted in the late spring or after growth starts. In general broadleaf trees should be transplanted only when the leaves are off. They may be transplanted in the fall more safely than conifers which mostly retain their foliage all winter. If evergreens are transplanted in the late fall, unless they are mulched or covered with snow during the winter months, they are likely to evaporate moisture from their foilage while the roots, which have not yet become established in the soil, are unable to supply more moisture. As a result they may dry out and die. The same thing may take place in the case of late spring planting after vegetation has started, resulting in the death of the trees.

Evergreens are, as a rule, more delicate than broadleaf trees and must be handled more carefully. Some of the broadleaf trees, such as box elder, poplar and silver maple, have a great deal of vitality and will stand considerable carelessness and exposure in transplanting. Small evergreens, such as two-year-old seedlings which are only a few inches high, may be safely transplanted in the fall in those parts of the State where there is sufficient snow on the ground all winter to cover them and keep them from drying out. Occasionally evergreens may be safely planted in the latter part of August or early in September, for, if weather conditions are favorable, they will become established before cold weather sets in.

METHOD OF PLANTING

In planting trees the hole should be dug slightly deeper than necessary to take the roots when spread in a natural position. The tree should be set from one-half to two inches lower in the earth than it was in the nursery. Fine, moist soil should be packed around the roots and then the coarser soil drawn into the hole and packed firmly with the foot. A layer of loose earth should then be scraped around the tree in order to retain the soil moisture. It is seldom necessary to use water in planting small forest stock, but if used it should be applied very liberally in the hole before planting.

In carrying the small trees about the roots should be kept moist and protected from the sun and wind. It is best to carry the trees in a bucket containing a thin mixture of mud and water or else in a basket, keeping the roots covered with a piece of wet burlap or moss.

In establishing a forest plantation the objects in view should be borne fully in mind. Mistakes made in the selection of species or in spacing may mean a loss of many years. It is often not realized how long it takes for trees to reach merchantable size or that trees in a plantation behave differently than those in the open.

A tree planted in the open, for shade or ornament, tends to branch low down and to retain its lower branches. Trees planted in close formation tend to grow tall with few side branches. The first tree will produce but little and poor grade lumber. The latter tree will yield more timber of higher grade. Trees planted close together are forced to grow straight and to form few strong side branches because the light comes from overhead. The leaves on the side branches die from lack of light and the branches themselves fall off in time. This is called self-pruning and is a result of close spacing. Some trees, such as the spruce, hemlock and beech will stand a large amount of shade without losing their foliage. Such trees may be used for underplanting in underbrush or open woods. Other trees, like the red pine, birch and yellow poplar, will not stand much shade and can be planted only in the open. It is often desirable to use a mixture rather than a single species, as the danger of loss from insects or fungi will be reduced and better utilization may be made of the soil. For this purpose a tree tolerant of shade may be alternated with one demanding light. The best spacing for an average forest plantation is 6 by 6 feet, requiring approximately 1200 trees to the acre.

SOIL REQUIREMENTS

Trees differ in their soil and moisture requirements. Some will do well on sandy soil. Others require deep moist soil.

Trees may be classified according to the soils upon which they do best. In establishing a forest plantation only those trees should be selected which are adapted to the soil in question. It should be noted, however, that trees will grow upon a great variety of soils and that the moisture conditions are of prime importance. Trees may be planted for ornament or shade upon a soil which is not their first choice. Nearly all trees will grow upon a better soil than that on which they occur naturally. The following list shows the general type of soil upon which certain species of trees may ordinarily be planted:

Light sand—Jack pine, Scotch pine, red pine, poplars, box elder.
Gravel—Red pine, Scotch pine, Norway spruce, chestnut.
Sandy loam—White pine, red pine, Norway spruce, red oak, poplars, maple.
Loam—Norway spruce, white pine, European larch, white ash, oaks, maples, beech.
Heavy soil—Walnut, hickories, ash, basswood, silver maple.
Swamp soil—Silver maple, sycamore, tamarack, balsam, white cedar.

TREES FOR VARIOUS PURPOSES

Trees may also be classified according to their ability to produce wood for certain purposes in the shortest time, as follows:

Lumber—White pine, red pine, ash, basswood.
Pulp—Norway spruce, poplar, basswood, larch.
Excelsior bolts—Basswood, poplar, willow.
Poles and posts—Larch, red pine, red oak, jack pine, catalpa.
Ties—Larch, red oak, jack pine, red pine.

TREES FOR PLANTING

Trees grow at different rates depending on the species and the location or character of the soil and climate where they are planted. Some species, like the jack pine, grow rapidly at first but are later surpassed by other species such as the red and white pines. Some trees are comparatively short-lived and while they may grow rapidly for a number of years do not last long enough to give satisfaction. The Carolina poplar is one of the fastest growing trees in Michigan but it is short-lived and is subject to attack by the poplar borer which is likely to destroy it. The black locust, also, is subject to attack by an insect, the locust borer, which practically precludes its successful planting in the State. The silver maple is a fast growing tree but is comparatively short-lived and the wood is of little value. The oaks and sugar maples are slow growing trees. The following are some of the more important trees for forest planting in this State:

WHITE PINE

White pine has probably been used for forest plantations more than any other tree in Michigan. It is a native of the State and does well on deep, light, moist and sandy soils. It grows quite rapidly after it has

passed the seedling stage and in good locations will grow about two feet in height a year. The lumber is valuable. Box boards will be produced in about 30 years. For forest plantations it is best to use small seedlings, 2-year-old stock, spacing the trees 6 by 6 feet. The planting of white pine should be limited to certain counties, as it is subject to a disease, the white pine blister rust, which has one generation on the white pine and the next on currant or gooseberry bushes. This disease has gained considerable headway in the East and in adjoining states, but so far has not appeared to any extent in Michigan. It can only spread when the two hosts, currants or gooseberries, both wild and cultivated, and white pine, are comparatively near together, within three hundred yards of each other. In many localities in Michigan, currants and gooseberries are of commercial importance and in such localities white pine should not be planted, since, if the disease appears, one or the other of the hosts must be destroyed in order to eradicate it. The counties where currant and gooseberry culture is of importance and where white pine should not be planted at present are those along the west side of the State from the Indiana line to Traverse City, as well as Kent, Newaygo, Kalamazoo, Washtenaw, Oakland and perhaps a few others.

RED OR NORWAY PINE

Red or Norway pine is very similar in rate of growth to white pine but it will do better on poorer, sandier soils. The wood is quite similar to the white pine, though a little heavier and harder, and is used for the same purposes. The red pine has thinner foliage than the white pine, it prunes itself of side branches better and is not subject to serious injury by insects or fungi. Owing to scarcity of seed, red pine seedlings are difficult to obtain but where they can be secured it is one of the best trees for forest plantations on the poor qualities of soil. A rather wider spacing may be used with red pine than with white pine as the trees will prune themselves of side branches more readily. A wider spacing reduces the number of trees required per acre and so reduces the cost and labor of planting. This is of importance in the case of red pine as the planting stock is scarce and more expensive than some other trees. It is often planted in mixture with white pine or Norway spruce, the species being alternated with a spacing of 6 by 6 feet.

JACK PINE

Jack pine will do well on dry sandy soil. It is a tree which grows fast at first but slows down later on and never reaches a large size. The wood is soft and light, and not durable in contact with the soil unless it has been treated with creosote or some other preservative. After such treatment it may be used for fence posts. The wood will undoubtedly be used for paper pulp within a few years and after that it will be more extensively planted than at present.

SCOTCH PINE

Scotch pine is not a native of Michigan but has been used quite extensively in the State. It does well on dry sandy soil. It is very similar to jack pine in habits of growth, although the timber is rather better. Two-year-old seedlings are a good size for field planting with a spacing

of 4 by 4 feet. Much of the Scotch pine which has been planted in this country has had its source in seed collected in central Germany. These trees become crooked and stunted and do not produce a good quality of timber. Trees grown from seed collected in the Baltic provinces of Russia, called the Riga variety, produce much better timber. This is the variety which should be planted.

An eight year old plantation of European larch on a sand ridge at St. Charles. The trees at the left have been pruned to a height of six or seven feet.

EUROPEAN LARCH

European larch is similar to our native tamarack but is not quite so subject to defoliation by the larch saw-fly. It is a deciduous conifer, losing its foliage in the winter. It does best on well-drained but moist soils. It will not succeed in swamps as will our native tamarack. It grows rapidly and the wood is heavy and durable in contact with the soil. It should produce fence posts in about 20 years. Extensive plantations are not advisable owing to danger of the larch saw-fly but it can be used as a filler with other species. Two-year-old seedlings are a good size to use. A spacing of about 10 by 10 feet is best, as the tree will not stand any shade and closely spaced stands result in the death or stunting of the trees, or a spacing of 12 by 12 feet may be used, interplanting with a shade-bearing, slower growing species, such as red oak, Norway spruce or white pine. Larch starts growth early in the spring and is subject to injury by late frosts.

NORWAY SPRUCE

Norway spruce, while not a native of this country, has been very extensively planted, chiefly for ornament. It is a fast growing tree and the wood is valuable for paper pulp. It does well on nearly all soils, except clay or very dry soils. It forms a dense, persistent crown, and is therefore suitable for windbreaks. It is used for Christmas trees and is the best tree to plant for this purpose. It reaches Christmas tree size in 5 or 6 years if small transplants are used for planting. It may often be used with advantage as a filler in plantations of other species and at the end of a few years be cut out and sold for Christmas trees. Four-year-old transplants are best. A close spacing, about 4 by 4 feet, is necessary in order to make the trees prune themselves and, if timber production is desired, it is advisable to cut off the lower branches when the trees are about 15 feet tall.

WHITE ASH

White ash is one of the faster growing hardwoods which produce valuable lumber. It does well on the better soils, where it may be mixed with pines or other species. It makes good fence posts if treated with preservative. It is probably better to plant it in mixture with other species than by itself. A close spacing, about 4 by 4 feet is best, as otherwise the tree tends to become crooked.

SILVER MAPLE

Silver maple grows rapidly but is short-lived and is of little value at present. As fence posts become scarcer, however, non-durable wood of fast growing species will undoubtedly be used and treated with creosote or wood preservative in order to lengthen its life. Silver maple will be a good tree for such use. It grows best on moist soils. It is used chiefly where a rapid growing shade tree is desired, but even then it is rather undesirable. A spacing of about 6 by 8 feet is advisable for forest plantations.

SUGAR MAPLE

Sugar maple has been planted to some extent in Michigan for sugar bushes and woodlots. It does well on any good soil but it grows rather slowly and takes a good many years to reach merchantable size. It is an excellent tree for roadside or street planting where good sized stock can be used. For timber production a spacing of 6 by 6 feet is advisable in order to make the trees prune themselves. For sugar bushes a spacing of 10 by 10 feet is better. Sugar maple may be planted in small openings in existing woodlots where it is desired to increase the percentage of this species. Many sugar bushes could be improved in this manner.

CATALPA

Catalpa will succeed in the southern part of the State but is subject to frost injury further north. It will grow on moist, well drained, fertile soil. Under favorable conditions it grows rapidly and the wood makes durable fence posts. It does not reach large size and requires pruning in order to make a straight stem. The seed should be soaked for twenty-four hours in water before planting. It should be planted only in the

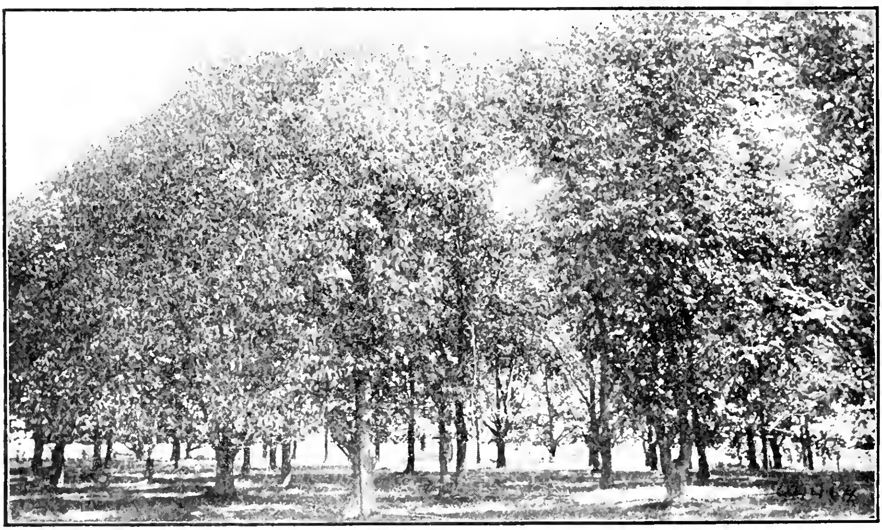
southern counties. The trees may be cut back to the ground early in the following spring after planting. The resulting sprouts will grow vigorously. The lower side branches should be pruned for a few years in order to force the tree to grow straight. The trees should be planted about 6 by 6 feet apart.

BASSWOOD

Basswood grows rapidly on good soil. The wood is valuable and it is a good tree to plant in favorable locations, either in pure stands or mixed with other species. Small seedlings are best to use, with a spacing of 6 by 6 feet.

RED OAK

Red oak does well on rather sandy soil in the southern part of the State. The other oaks grow too slowly for profitable planting. The acorns may be planted directly in the field or small seedlings may be used with a spacing of about 6 by 6 feet. If the acorns are planted in the field, three or four should be planted together in prepared spots. They may be coated with red lead to prevent destruction by rodents. The red oak does not make very durable fence posts unless treated with a preservative. It should make posts under favorable conditions in about 30 years.



A fifty-seven year old chestnut plantation at Greenville. The trees were transplanted when two years old and cultivated with hoed crops for about ten years. The plantation is on well drained soil.

CHESTNUT

Chestnut is hardy in the southern part of the State. It does well on rather poor, sandy soil but grows faster on better soils. The wood is very durable in contact with the ground and makes good fence posts as well as valuable lumber. The nuts should be stratified in moist sand over winter and planted in the garden in rows in the spring. The small trees should be set out in their permanent places when one or two years

old. The trees begin bearing nuts when about 12 years old. For forest plantations a spacing of 6 by 6 feet is best. Where nuts are desired a much wider spacing, not less than 20 by 20 feet, is necessary.

A number of chestnut plantations have been established in Michigan. One plantation that is now 37 years old in Van Buren county has been bearing nuts for many years. The average tree is 14 inches in diameter and 65 feet tall and some years the plantation has yielded 15 bushels of nuts to the acre. Another plantation in Berrien county is now 45 years old and covers 4 acres. The trees were planted with a spacing of 28 by 32 feet. The average tree is 20 inches in diameter and 65 feet tall. The yield in nuts varies from almost nothing up to 9 bushels per acre. A plantation in Van Buren county which is 12 years old is now bearing. The price of the nuts on the market is comparatively high owing to the fact that the trees in the East have been largely destroyed by the chestnut blight disease which has resulted in a great reduction of the supply of these nuts. Trees for planting should be obtained from within the State or from western states and not from the East owing to danger of introducing this disease.

BLACK WALNUT

Black walnut is one of the best hardwoods to plant in the southern part of the State on fairly moist, fertile soil. It grows quite rapidly, the wood is very valuable and was in much demand during the war for gun stocks and airplane propellers. Owing to this demand a great deal of black walnut was cut and its replacement is desirable. The heartwood is durable in contact with the soil and makes good fence posts. In addition to its timber value the nuts are edible. There is a great difference in the nuts, some are small, some thick-shelled, and some are comparatively thin-shelled. By selection trees can be produced that will bear nuts with comparatively thin shells and of good quality. The black walnut develops a strong taproot early in life making it difficult to transplant large trees. The seed may be planted where the trees are desired, but squirrels are very likely to dig them out. It is best to plant the nuts in the garden in the fall, and the shucks may be left on. The small trees should be transplanted to their permanent locations when one year old. For forest plantations a spacing of 8 by 8 feet is good, interplanting with Norway spruce or red oak so as to force the black walnut to grow straight, as otherwise it will develop many low branches. For nut production a wider spacing should be used.

The Persian walnut is not hardy in Michigan unless grafted upon hardy stock. There are a few Persian walnuts that have been so grafted upon black walnuts which are doing well, but the tendency is for the scions to die back leaving the black walnut to grow.

RATE OF GROWTH

In considering the growth of forest plantations the amount of timber that is produced per acre is a better indication of the profitableness of planting any species or mixture of species than is the rate of growth of individual trees. A plantation of European larch, which is a fast growing tree, will not produce so much timber to the acre as will a plantation

of white pine. The white pine can be grown closer together than the larch and while an individual tree in the open does not grow so fast the plantation will produce more timber to the acre.

The following table gives the diameter and height of the average tree and the diameter of the maximum tree for a few existing plantations in the southern part of the State and the yield in timber is given in cubic feet. A standard cord of wood contains 128 cubic feet of space of which, in a stacked cord, about 30 per cent is air space between the sticks, so that an average standard cord contains about 90 cubic feet of solid wood.

Species.	Age, years.	Number of trees per acre.	Diameter average tree, inches.	Diameter maximum tree, inches.	Height average tree, feet.	Yield per acre, cubic feet.
White pine	8	500	1.3	2.7	9	
White pine	12	600	2.2	5.0	15	300
White pine	18	680	6.0	9.0	28	1,600
White pine	24	416	8.2	12.2	42	2,580
Norway spruce	20	1,120	5.0	8.0	24	1,456
Mixed hardwoods	42	162	9.0		50	2,264
*Chestnut	12	100	4.0	7.5	20	78
*Chestnut	37	67	14.4	20.0	65	2,100
*Chestnut	45	51	19.9	27.0	65	2,700
Catalpa	11	1,280	3.1	7.3	23	760
Catalpa	12	834	4.0	8.0	24	850‡
Catalpa	25	100	10.0	15.0	45	810
Black locust	10	620	3.0	8.0	16	173
Honey locust	23	260	5.0	12.0	40	650
Black walnut	23	524	3.0	10.0	20	260
Carolina poplar	9	700	3.5	6.0	28	700
White ash	10	2,800	1.0	1.5	12	

*Planted with wide spacing for nut production.
‡About 80 fence posts having already been taken out.

Figures of the yield per acre of some plantations in other states are given below. These data have been compiled from various Government and State reports.

Scotch pine and larch, New York, 25 years old, 13,000 board feet per acre.
Scotch pine, New York, 35 years old, 27,000 board feet per acre.
Silver maple, Illinois, 9 years old, 16.2 cords per acre.
Silver maple, Iowa, 20 years old, 20.1 cords per acre.
Black walnut, Indiana, 12 years old, 7.5 cords per acre.
Black walnut, Illinois, 38 years old, 33.8 cords per acre.
White pine, Iowa, 21 years old, 4,760 board feet per acre.
White pine, New York, 28 years old, 24,000 board feet per acre.
White pine, Massachusetts, 38 years old, 29,000 board feet per acre.
White pine, Massachusetts, 43 years old, 37,716 board feet per acre.
White pine, Massachusetts, 55 years old, 43,796 board feet per acre.
Norway spruce, New York, 22 years old, 10,000 board feet per acre.

White pine windbreak at East Lansing, 22 years old. There are two rows of trees, the average height of which is 29 feet.

WINDBREAKS

Windbreaks or shelter belts are useful in diminishing evaporation from soil and plants. The influence of a windbreak is proportional to its height and density. The shade cast by the trees has, however, a damaging effect on crops and the roots of the trees, if far reaching, may sap the soil moisture for some distance on either side. Species should, therefore, be used which have compact or deep reaching root systems. A windbreak can be used for the production of fence posts or poles. From the white pine windbreak at the College the seed is collected each seed year, in 1918 one hundred pounds of seed being obtained, worth at that time $2 a pound.

For windbreaks a tree that retains its lower branches and which makes a dense screen is desirable. It is also usually desired to use an evergreen which retains its foliage all winter and to use a tree that grows rapidly and which will give quick results. Of such trees the Norway spruce, Scotch pine, Austrian pine and, where there are no currant or gooseberry bushes in the neighborhood, white pine are the best. For windbreaks it is best to plant a double row of trees, alternating the trees in the rows and spacing them about 10 feet apart in the row with about 8 feet between the two rows. If a single row of trees is used a closer spacing is necessary so that the branches will interlace and make a dense screen.

If it is desired to produce fence posts, osage orange may be used. They can be cut back every few years and will sprout from the stumps. Silver maple and box elder are fast growing trees which are sometimes used but the roots are far reaching and the branches are often broken by heavy winds.

The following table gives the growth of trees in a few windbreaks in the State:

Species.	Locality.	Soil.	Age, years.	Diameter, average tree, inches.	Height, average tree, feet.
Norway spruce	Grand Haven	Sandy	20	6.7	26
Norway spruce	Holland	Sandy	28	9.1	48
Norway spruce	Holland	Sandy	30	8.4	51
Norway spruce	Holland	Sandy	35	11.0	55
White pine	East Lansing	Sandy loam	22	9.1	29
Carolina poplar	Grand Haven	Sandy	17	10.2	45
Carolina poplar	Holland	Sandy	28	17.4	65
‡Osage orange	Okemos	Sandy loam	33	3.0	23

‡This windbreak has been cut back occasionally. The osage orange will sprout from the stump.

EXPERIMENTAL PLANTATION AT GRAYLING

In 1888, Dr. W. J. Beal, at that time Professor of Botany at the Michigan Agricultural College, made an experimental plantation of a large number of different species of trees on the lands of the College experimental farm at Grayling in Roscommon county. This plantation is now 32 years old and offers a valuable example of what may be expected in the way of forest growth under such conditions.

The soil is dry and sandy, typical of much of the jack pine plains of the State. The native species common on such soil in this locality are scarlet oak, jack and red pine. The experimental plantation originally contained the following varieties of trees. The list gives the number of trees of each species used and also the height of the seedlings at the time of planting.

100 Canoe birch, 10 in.
50 Camperdown elm.
20 Sycamore maple.
20 Hackberry, 12 in.
100 Black ash, 6 in.
50 Red elm, 6 in.
100 Red maple, 6 in.
100 Hardy catalpa, 18 in.
1000 Black locust, 16 in.
200 Silver poplar cuttings.
100 Balsam poplar cuttings.
100 Wisconsin weeping willow cuttings.
100 Silver maple, 24 in.
100 American beech, 18 in.
100 American elm, 12 in.
200 Russian mulberry, 6 in.
200 Large white poplar cuttings.
100 Balm of Gilead cuttings.
100 White willow cuttings.
100 Purple willow cuttings.
A few Lombardy poplar.
100 Yellow willow cuttings.
100 American arborvitae, 6 in.
500 White pine, 10 in.
100 Red cedar, 9-12 in.
100 Sugar maple, 6 in.
100 White ash, 1 ft.
100 Honey locust, 12 in.
50 Box Elder, 24 in.
100 Norway maple, 12 in.
50 European elm.
20 Kentucky coffee trees, 6 in.
100 Black cherry, 12 in.
50 Basswood, 4 in.
100 Scotch pine, 9-12 in.
100 Norway spruce, 9-12 in.
200 European larch, 9-12 in.
100 Green ash, 1 ft.
100 Yellow birch, 6 in.
50 White spruce, 9-12 in.
200 Red pine, 4-6 in.
A few pitch pine.

The land was plowed and harrowed and the trees set in rows 4 feet apart and 4 feet apart in the row. The plantation covered about one acre. For the first 2 or 3 years after planting the plantation was cultivated but after that no care was given it.

Of the 40 odd species planted less than half remain and of these only about a half dozen, all conifers, may be said to have succeeded, and only 3 or 4 have demonstrated their ability to grow to advantage under these conditions of soil and moisture.

HARDWOODS

Of all the hardwood species which have survived none have shown any possibilities. They have largely failed even to develop to tree form and are mostly merely a scrubby growth, being either unable to withstand the severity of the climate or the infertility of the soil.

The largest elm is only 4 inches in diameter as compared with upwards of 8 inches for many of the conifers. Two Lombardy poplars are 40 feet tall and 7.5 inches in diameter. Most of the others have been broken by wind or ice. Some of the other species of poplar attained rather straggling tree forms before being killed back by adverse conditions. The black locust has succeeded in obtaining a foot-hold and has spread out into the field on both sides but it does not assume tree form. The leaders are killed back almost annually by late frosts and the result is a growth of valueless brush. A few trees in the interior of the plantation have attained a height of 20 feet and a diameter of 3 inches. It is noteworthy that no oaks were planted, although certain species of oak occur naturally on similar sites.

The forest plantation on sandy soil at Grayling.

CONIFERS

Of the 9 species of conifers planted, specimens of all still exist but only a few have apparently demonstrated their ability to succeed under these conditions, the red pine, white pine and Norway spruce. Two others show possibilities, the Scotch and pitch pines. The others have either made

such slow growth or grow under such disadvantages that their use for forest planting on a large scale in similar localities should not be attempted.

The conifers arranged in order of their success are red pine, Norway spruce, pitch pine, white pine, Scotch pine, European larch, red cedar, white spruce, and white cedar.

The red pine has succeeded the best of all the species planted. Next to the Scotch pine it has the largest average diameter and its average height growth is practically the same as that of its nearest competitor, the Norway spruce. The largest red pine is 10.2 inches in diameter and the smallest, 3.5 inches, and there are very few trees under 5 inches in diameter. The planting distance was a little close for red pine and resulted in the suppression of many trees. The average diameter is 6.8 inches, making an average mean annual diameter growth of 0.2 inches. The average mean annual height growth is 0.8 feet.

Of the 100 Norway spruce planted, 56 remain. Probably over 30 have been cut for Christmas trees, so that the percentage of survival has been high. The maximum diameter is 7 inches. Many of the trees have been badly suppressed and so there is much variation in size. The average mean annual growth in diameter is 0.13 inches and in height, 0.8 feet. The Norway spruce has been attacked to some extent by the spruce gall which, however, has done no serious damage. Probably part of the good growth of this species is due to the fact that it was planted in the two outside rows and so had more light and growing space than some of the others, but even so it has proven itself capable of growing and doing well under the soil and moisture conditions present which would generally be considered as too severe for the species. The trees appear to be still growing at a good rate. It is commonly stated that Norway spruce is short-lived in this country, seldom lasting over 50 years.

At least 2 pitch pine were planted, having evidently been mistaken for Scotch pine. Although a light-requiring species and growing in the interior of the plantation they have done well. Their average mean annual growth in diameter is 0.18 inches and in height, 0.7 feet. While it would be unwise to generalize from 2 trees the species seems to have promise on this site and it is known to produce better lumber than jack pine.

There were planted originally 500 white pine, nearly three times as many as any other species. White pine is now the most numerous tree in the plantation. The average mean annual growth is 0.16 inches in diameter and 0.7 feet in height. The white pine is in general less healthy than the red pine and wherever in the plantation the two trees grow side by side the red pine is the leader.

Of the 100 Scotch pine planted, 11 trees remain alive. They have developed a very poor form and are largely crooked and short-stemmed with branches clear to the ground. They are badly infected with a fungus disease, a peridermium, which has destroyed their form and resulted in the death of several individuals. Therefore, despite the good average dimensions of the trees, they cannot be regarded as having succeeded. It is probable that if they had not been attacked by this disease and had been planted closer together, the results would have been much better. The largest of the Scotch pine is 10.5 inches in diameter and the

average tree is 8.1 inches, giving an average mean annual diameter growth of .23 inches. The mean annual height growth is 0.8 feet.

Two hundred European larch were planted, of which only three remain. Of these two are healthy and growing rapidly, the third is partially suppressed and dying. Their average mean annual growth in diameter is 0.16 inches and in height, 0.7 feet. Apparently the species is able to do well if it gets a good start and is not suppressed. It is, however, liable to injury by late frosts.

Of the 100 red cedars planted, only about 6 remain. Many, however, have been cut for Christmas trees which partly accounts for the high rate of loss. The red cedar is very intolerant of shade and many of the trees in the interior of the plantation were suppressed. Its rate of growth has been very slow, the trees averaging only 3 inches in diameter. This species might be used for ornamental planting in this part of the State but its slow growth precludes its use for forest planting.

Fifty white spruce were set out in the rows next to the Norway spruce. There remain about a half dozen specimens, varying in diameter from 2 to 3.5 inches and from 15 to 20 feet in height. Although the white spruce was less favorably situated than the Norway spruce, the great difference in growth cannot be laid entirely to that, and seems to be conclusive evidence that for planting on relatively dry sites, for a short rotation at least, the Norway spruce is the better tree. Further north, however, the white spruce might make the better showing.

Of the 100 arborvitae, or white cedar, originally planted, several remain and their average diameter is 2 inches. The site is too dry for this species which is a tree requiring considerable soil moisture.

The following table gives the diameter and height of both the maximum and average trees of various species in the plantation 32 years after it was established.

	Maximum diameter, inches.	Maximum height, feet.	Average diameter, inches.	Average height, feet.
Red pine	10.2	35	6.8	28
Norway spruce	7.0	35	4.6	28
Pitch pine	6.7	30	6.3	25
White pine	7.7	30	5.6	24
Scotch pine	10.5	30	8.1	27
European larch	6.5	25	5.5	25
Red cedar	3.5	20	3.0	20
White spruce	3.2	20	2.7	18
White cedar	2.5	15	2.0	11

INTRODUCTION

The fertility of the soil is the greatest of our natural resources. It is highly desirable, therefore, that we have at our disposal all the information concerning our soils that it is practicable to gather. The location of different soil classes or kinds of soil, the nature of their subsoils, the drainage conditions and their agricultural possibilities should be known. Moreover the amount of the several elements of plant-food and the lime requirement of the different soils should be determined so that they may be most intelligently managed.

Certain members of the Soils Section of the Michigan Agricultural College Experiment Station prior to May 1st, 1920, did a great deal of general or reconnaissance soil classifying and mapping. Samples of the representative soils of several areas were collected and analyzed for their plant-food constituents, observations made on the agricultural conditions and reports written. Since that date the Soils Section of the Michigan Agricultural College Experiment Station entered into a cooperative agreement with the U. S. Department of Agriculture, Bureau of Soils, whereby the soils of the State are to be classified and mapped in detail. Under this agreement the salaries and expenses of the field men are shared equally by these organizations. In addition the former pays for the cost of publishing the soil reports and maps, which means that for each dollar the State spends the U. S. Department of Agriculture furnishes about one and one-half dollars.

It has been deemed advisable to publish the results of the preliminary or general soil surveys at this time rather than to wait for the more detailed report. Colored maps were not printed because of their high cost and it did not seem practicable to expend several hundred dollars for such in this, our preliminary work.


LAKE SUPERIOR
LAKE HURON
LAKE MICHIGAN

DESCRIPTION OF AREA

Special Bulletin No. 104

AREA SURVEYED

BY M. M. MCCOOL AND G. M. GRANTHAM—SOILS SECTION

A reconnaissance or general soil survey was made of the Detroit area including Monroe and parts of Wayne, Washtenaw and Lenawee counties. All of Wayne was surveyed with the exception of the northwest two-thirds of Northville and Plymouth townships. In Washtenaw parts of Saline, York, Augusta, Ypsilanti and Superior townships are included. About half of Lenawee county has been surveyed including all of Fairfield, Ogden, Riga, Deerfield, Blissfield, and Ridgeway townships and the southeast part of Seneca, Madison, Palmyra, Raisen and Marion townships. The entire district is comprised of about 1,543 square miles of 987-520 acres. The area is situated on the west side of Lake Erie, the Detroit River and part of Lake St. Clair. It is bounded on the north by Macomb and Oakland counties and on the south by the State of Ohio. It is in about the same latitude as Boston, Massachusetts, and in about the same longitude as Columbus, Ohio.

Fig. 1.—There are several sand ridges in the area which are said to have been former lake shore lines. These vary in height, the soils are quite light in texture, low in nitrogen, humus, lime and phosphorus.

The Detroit area includes a small part of the old lake basin which covers an extensive area in eastern Michigan and northern Ohio. The outlet to this old glacial lake has been lowered until, at the present time, large areas of former lake bottom are very productive lands.

The surface features may be conveniently divided into five distinct divisions. First, the sand drift which extends parallel to the shore line near the center of Wayne and Monroe counties, touching only the extreme southeast corner of Washtenaw county and extending through about the center of the old lake bed district of Lenawee county.

Second, the level to undulating lands which are along the shore line extending inland from five to fifteen miles. Narrow strips ranging from one to five miles wide are found between the sandy drift in central Monroe county and in the extreme southern part of Wayne county. The same surface features are to be found bordering the west side of the area and are much more extensive than those along Lake Erie and the Detroit river.

Third, the old deltas formed where streams entered the Lake. These formations are most prominent where the larger streams flow from the upland on to the old lake bed district. Such formations are very distinct east of Adrian, Saline, Ypsilanti, Plymouth and Northville.

Fourth, gravelly ridges ranging from four to twenty feet above the level land and extending approximately parallel to the present lake shore line and for the most part found near the upland soils along the west side of the old lake bed. Such ridges were on the shore lines of the Lake and may be easily distinguished from the sand ridges by the coarse material and an occasional pocket of gravel.

Fifth, the river flood plains and terraces which lie along the larger streams. Such surface features are not wide in extent yet furnish excellent farming land because of their fertility and thorough drainage. Few terraces occur, the most important one being near Bellville in Wayne county which extends about six miles along the Huron river and ranges from a few rods to approximately three miles in width.

Very little rough or broken land is to be found in the area. The bluffs along the rivers and streams are very low ranging from only a few feet to twenty to thirty in the more rolling land. The streams have ample fall for drainage yet the channels are relatively new compared to the rough and broken lands along streams outside this area.

The general slope of most of the area is toward Lake Erie and the Detroit river. The elevation at these points ranges from 575 to 600 feet above sea level, the rise being gradual back to the old shore lines of the Lake where near the upland the elevation varies from 600 to 800 feet.

MARKETS

Detroit and Monroe are the two largest cities in the area. Adrian, Ypsilanti, Ann Arbor, Michigan and Toledo, Ohio, are others located close to the area and afford excellent markets and shipping points for farm produce.

TRANSPORTATION

Transportation facilities are excellent. The main railroads of importance to the area are the Wabash, Lake Shore and Michigan Southern, Pere Marquette, Michigan Central, Ann Arbor, Grand Trunk and Detroit and Toledo. Numerous electric lines radiating from Detroit and Toledo are also a valuable asset. The main highways surrounding Detroit are excellent. It is possible to travel from 10 to 30 miles out of Detroit on concrete roads.

Other than the main roads just mentioned the roads throughout the entire area are poor, yet good roads are being constructed quite rapidly.

Water transportation is well developed. A greater part of the livestock raised in Monroe and Lenawee counties is marketed in Cleveland and Buffalo by this means.

DRAINAGE

The most important factor limiting maximum crop production in the greater part of the Detroit area is lack of drainage. Thousands of acres are seeded late in the spring because of inadequate means of carrying away the heavy rainfall. The level formations so characteristic to the old lake bed area do not allow a rapid removal of surface water and the surface soil is usually rather heavy and impervious thus impeding under drainage. The subsoil is represented by three kinds namely, impervious clay, sandy clay, and granular clay or "honey comb," yet only small areas of the two latter conditions occur. Where no artificial drainage is present the loss of water takes place by evaporation and seepage both of which remove water very slowly.

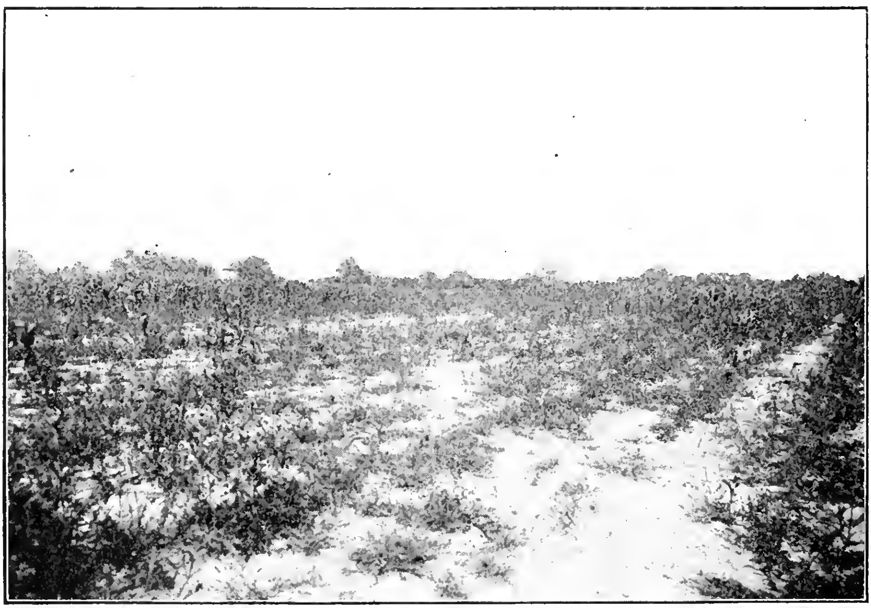


Fig. 2.—Improper drainage is the chief limiter of crop yields over much of this area.

The natural drainage is well established for the level land. The rivers Raisin, Huron, Ecorse and Rouge and creeks Otter and Swan with their tributaries are the principal natural drainage channels for the area.

Artificial drains are being built in the form of dredge ditches as well as shallow surface field and tile drains. Only a few dredge ditches are constructed because for the most part outlets for smaller drains are easily obtained. The larger per cent of the field drains consist of "dead furrows"

made when plowing the land. Such drains carry away the surface water readily but do not drain the saturated soil and subsoil, and moreover require considerable time in their construction each year and result in appreciable amounts of waste land in cultivated fields.

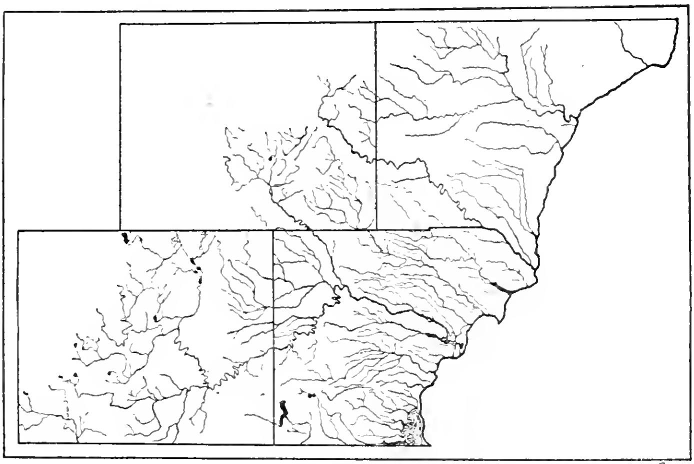


Fig. 3.—Natural drainage courses usually afford ample outlet for tile drains.

CLIMATE

The climatic conditions of the Detroit area are fairly uniform. Near Lake Erie and the Detroit river frosts are retarded somewhat but this is only for a few days. The nature of the topography does away with practically all frost pockets.

Climatological data from three stations of the U. S. Weather Bureau are given. Data from the Detroit station are representative of the water front while that taken from Plymouth represents some of the highest land in the entire area. The latter being located on one of the delta formations near the glaciated uplands. Eloise is located on one of the medium elevations of the area and about equidistant from the shore and the uplands.

NORMAL MONTHLY, SEASONAL AND ANNUAL TEMPERATURE AND PRECIPITATION AT DETROIT, ELOISE AND PLYMOUTH.

	Detroit.		Eloise.		Plymouth.	
Length of Record	47 years.		21 years.		21 years.	
Month.	Temp. °F.	Rainfall, Inches.	Temp. °F.	Rainfall, Inches.	Temp. °F.	Rainfall. Inches.
December	28.5	2.39	26.4	2.17	27.9	1.42
January	24.3	1.98	24.6	2.19	24.0	1.95
February	25.0	2.19	20.8	2.15	22.1	1.46
Winter	25.9	6.56	23.9	6.51	24.6	4.83
March	32.9	2.37	35.2	2.16	33.8	1.52
April	45.5	2.33	46.3	2.30	46.2	1.86
May	57.0	3.27	57.3	3.07	58.4	3.08
Spring	45.1	7.97	46.3	7.53	46.1	6.46
June	67.8	3.89	66.9	2.69	68.5	3.19
July	72.0	3.48	72.8	3.29	71.8	3.45
August	69.9	2.77	70.2	2.77	70.2	1.95
Summer	69.9	10.14	70.0	8.75	70.2	8.59
September	63.1	2.48	64.2	2.73	62.8	2.45
October	51.7	2.38	52.7	2.58	51.9	2.85
November	38.6	4.63	38.4	1.88	39.4	2.63
Fall	51.1	9.49	51.7	7.19	51.4	7.93
Year	48.0	34.16	48.0	29.98	49.0	27.81

The climate, from an agricultural standpoint, is quite desirable. The winters are of medium length with an average of approximately 45 inches of snow fall. The summers as an average are of sufficient length to mature the crops grown. The rainfall which normally is 30.8 inches is ideal for this location. The following data taken from four U. S. Weather Bureau Stations in the area give valuable information regarding the time of frosts and the average length of growing season.

Station.	Date of latest killing frost in spring.	Date of earliest killing frost in autumn.	Av. date of last killing frost in spring.	Av. date of first killing frost in fall.	Length of growing season in days.
Eloise	May 27	Sept. 18	May 8	Oct. 9	154
Detroit	May 31	Sept. 22	April 29	Oct. 13	167
Grape	May 28	Sept. 19	May 7	Oct. 13	159
Plymouth	May 28	Sept. 2	May 7	Oct. 13	149

Severe storms are very rare. Hail storms occasionally accompany heavy rains in the growing season and cause considerable damage to corn and oat crops. Such storms are only local, however, usually ranging from ¼ to ½ mile in width and from ¼ to 1½ miles in length. Records from this portion of Michigan show an average of 134 clear days per year, 101 days partly cloudy, and 130 days cloudy. The prevailing winds are from the southwest, the local winds, however, have an important bearing on this particular area because of the close proximity to the water. The differences in changes of temperature of the air over the land and water cause local winds, called lake breezes, which are important from an agricultural standpoint during the hot part of the season.

AGRICULTURE

The agricultural development was slow. The first agriculture started near Lake Erie and along the Raisin and Huron rivers on the higher and sandy lands, was due to ease of clearing and of tillage, and to natural drainage. As water transportation developed making accessible the markets of Detroit and Toledo, agriculture rapidly developed into an important industry. At present 74 per cent of this fertile lake bed is improved. The last to be developed (1850-1875) was the low land in the extreme southeastern part of Lenawee and the southern part of Monroe counties known as the "black swamp" by the Indians and French settlers. This includes some of the best agricultural lands in the United States.

Owing to soil and climatic conditions this area has a wide crop adaptation. Although the staple farm crops are grown, there has been considerable change in the yields and crops grown since the area was first cultivated. Corn, wheat and potatoes were the first principal crops raised. The rapid depletion of the fertility of the sandy land lowered the yields, while the production increased on the heavy land because of artificial drainage. On account of the introduction of live stock, the proximity to large markets the aspect has changed until at present, the live stock, dairying, grain and hay farming and truck gardening have reached a high state of development.

While a greater part of the grain produced is fed to live stock on the farm, some is marketed. In the heavy land districts usually more grain is grown than can be fed to the stock but the reverse is true on the sandy land. Of the southern half of the area approximately 24 per cent of the improved land is seeded to corn annually while of the north half corn is grown on only 15

per cent. In the dairy districts corn is used mainly for silage while in the grain districts it is husked from the stalk and stored for feeding purposes. A greater part of the corn is grown on heavy land, the average yield thereon being 40 to 55 (72 lbs. ear corn) bushels per acre. On sandy land the yield is rather light being about 25 bushels per acre. There is a tendency to substitute rye and barley for corn as sources of grain for livestock.

Oats are quite extensively grown on both light and heavy land. Approximately 14 per cent of the improved land is seeded to this crop. In more recent years the oat crop is being replaced to an appreciable extent by wheat. The heavy land yields as an average about 50 bushels per acre while the sandy lands yield only about half this amount. Only a small per cent of the oats raised are fed on the farm.

The Wheat acreage is gradually increasing throughout the area. Fall sown wheat has not been winter killed to any great extent, for a number of years; this together with the high price accounts for the increased acreage. Practically all of this crop is grown on heavy land, the average yield being about 25 bushels per acre.

Barley has recently become an important crop and its acreage is gradually increasing. Its production is confined to the heavier soils, the average yield being about 40 bushels per acre. Most of this crop is grown for feeding purposes taking the place of corn when the supply of the latter is limited.

On sandy land, which is becoming depleted of its fertility, rye is one of the main crops. Most of the rye produced is marketed. The yields obtained are quite variable depending upon the fertility of the land. Potatoes is another important sandy land crop. The yield averages approximately 100 bushels per acre.

The Hay Crop consists mainly of a mixture of timothy and clover and occupies quite a large acreage throughout this area. The need of growing clover in order to maintain the fertility of the soil is generally recognized and for this reason the acreage of clear timothy is rapidly decreasing. While most of the hay crop is fed some is put on the market and shipped to eastern points.

Other Crops of minor importance which thrive when properly managed are buckwheat on poor sandy land, sugar beets on heavy land near beet factories or where they can be easily shipped, and alfalfa which is just beginning to be grown extensively in the area.

Truck Gardening occupies a very prominent position in the agriculture of this area. Along the lake front and in much of Wayne county truck farming predominates. Good transportation facilities in these districts make it quite easy to reach such excellent markets as Detroit, Toledo and Monroe. Most of the produce marketed is consumed in these cities yet some is shipped by rail and water to eastern markets such as Cleveland and Buffalo.

Fruit. Very little tree or bush fruits are grown other than for the farmers' individual needs.

Live Stock. The fattening of live stock is an important industry in most of the grain growing sections. The two principal classes of stock fed are hogs and beef cattle. In some sections lambs are fed with profit but as yet the number fattened is relatively small. Practically all of the hogs fitted for market are raised in this area but the reverse is true of the beef cattle and sheep. A large per cent of the live stock is put on the markets in Detroit, Toledo, Cleveland and Buffalo by the farmers who have fattened them.

The horses of this area are above the average of the State in quality. The

heavy soils necessitate the use of a heavier type of horses than is usually found on the sandy districts of Michigan.

Dairying is important to the area. Throughout Wayne county and along the lake in Monroe county the larger farms are devoted principally to dairying. In other sections this type of farming is secondary although many farmers keep from five to seven cows.

The general methods of farming that are followed are somewhat different from those practiced in other parts of Michigan, the systems used being practically the same as are employed in the corn belt districts of Ohio, Indiana and Illinois. Grains are threshed mainly from the shock in the field and corn for grain is husked from the standing stalk. Hay is stored in large barns, very little being stacked outside. Modern machinery is used in practically all branches of farming, the heavy land necessitating the best grades of farm machinery obtainable. The value of the farm buildings and their upkeep is generally directly proportional to the value of the land on which they are located. The farms of the heavy land districts are as well equipped in this respect as any in the United States; large stock and hay barns with well constructed silos are common, and the residences on this land for the most part are well constructed and supplied with modern farm home conveniences. The farm buildings and their state of repair on the sandy areas, as a rule, are not so commendable.

Commercial Fertilizers. A large amount of fertilizer is used throughout this entire area, complete fertilizers varying in composition being preferred by the farmers. In the sugar beet districts fertilizers with high potash content are in demand while in the grain growing districts phosphorus receives more emphasis. Local dealers in towns of Monroe and Lenawee counties handle from three to twelve car loads of fertilizer per year. In the northern half of the area the consumption is less because of greater amounts of available manure. Fertilizers are applied mainly to the wheat and corn crops, the amount applied varying from 100 to 400 pounds per acre with an average application of 175 pounds. Practically all of the fertilizer is distributed by means of drills with fertilizer attachments. Acid phosphate has been used in only a few cases but has given excellent results where employed. Very little lime has been used in this area. The sandy soils which have received an application have given good results while the heavy soils do not seem to respond to it. Different forms of lime are used but the ground limestone is the most popular, from 500 to 1,000 pounds per acre being used.

Barnyard Manure. Because of the large amount of live stock fattened in this area barnyard manure is produced in large quantities. Unfortunately the greater part of it is carelessly handled, large piles being exposed to the weather for long periods of time. Practically all of the manure is distributed by means of manure spreaders. Autumn applications are common on the undrained heavy soil since it is practically impossible to spread the manure in early spring.

The Size of the Farms Varies. In the grain and livestock farming districts the acreage approximates eighty acres. Nearer Detroit and Toledo, Ohio, farms are quite small averaging approximately eight acres. About 75 per cent of the farms on heavy land and 90 per cent of those on sandy soil are operated by the owners. Near Detroit a different condition prevails since the farms are owned largely by city men.

SOILS

The soils from this region are mainly those derived from glacial deposits. The reworking by water and wind, weathering and plant growth have changed the soils to a great extent. The surface soils are usually friable and well supplied with organic matter. The sandy areas are probably shore lines of ancient lakes but they have been reworked by both wind and water until all semblance of beach lines is now gone.

TABLE 1.—EXTENT OF DIFFERENT SOILS.

Soil.	Per cent of area.	Acres.
Clay loam	10	98,752
Silt loam	30	295,256
Brown sand	40	395,008
Sandy loam	15	148,128
Fine sandy loam	3	29,625
Sandy loam on gravelly subsoil	1	9,875
River flood plains	1	9,875

The underlying rock is limestone and varies from 10 to 300 feet from the surface. Where the limestone approaches the surface it is removed and used for agricultural lime, for road building and for other purposes. Between Detroit and Rockwood the rock lies near the surface and here large stone industries are established.

HEAVY SOILS

CLAY LOAM

Extent of Type:

This soil type is rather limited in extent covering approximately 10 per cent of the area. It includes the "black swamp" region so well known to the Indians and early settlers. It is most extensive in Lenawee county covering parts of Fairfield, Ogden, Riga and Deerfield townships. Whitford, Summerfield, Bedford and Erie townships in Monroe county, and Ecorse and Monguagon in Wayne county also have limited areas of this valuable soil.

Topography and Variations in Type:

The topography of the clay loam is level to slightly undualting. There probably is no other area of this extent in Michigan which presents such a flat surface feature.

The area is quite uniform in type yet the slight changes in topography are invariably followed by a change of type or variations in the same type. The lower lands contain a clay soil high in organic matter which makes them quite friable. The knolls are composed of much lighter soil than the level land and could correctly be classed as loam, however, the extent of these two variations in type is quite small and therefore they have not been isolated on the accompanying soil map.

Description:

The surface soil to an average depth of 10 inches is a black clay loam, quite friable due to the high content of organic matter. Occasionally in the lower layers of the surface soil there are yellow to brown mottlings. The subsoil is a yellowish brown clay well mixed from 10 to 20 inches with the larger silt particles. This stratum also contains grayish brown mottlings. Below 20 inches is a yellowish clay quite impervious to water. Occasionally a sandy clay subsoil is encountered just beneath the surface soil but at 20 inches it changes into the impervious clay so typical of this area. Granular subsoils are also to be found just beneath the surface soil but such variations are only small in extent.

Fig. 6.—Small grains are the principal crops grown on the heavy land. Usually the yields are satisfactory when the soil is properly fitted.

Drainage:

This type of soil has the poorest natural drainage of any in the area and has caused a demand for artificial drainage. Dredged ditches, surface field and tile drains have been constructed until now this network of channels carries away the water sufficiently for field crops to grow. Surface field drains are probably in use more than are tile because of their inexpensive installment, yet they necessitate an excessive amount of waste land in the cultivated field. Tile drains for the fields are quite expensive, the heavy subsoil necessitating the placing of laterals close together, however, they furnish the most efficient means of drainage. Field results show that for greatest efficiency tile lines should be placed not more than 4 rods apart. Where the sandy clay or granular subsoil occur tile lines can be placed from 6 to 8 rods apart and yet give efficient results. Although large amounts of money have been invested in drainage systems it can be truthfully said that the lack of drainage is still the first limiting factor to the most successful agriculture.

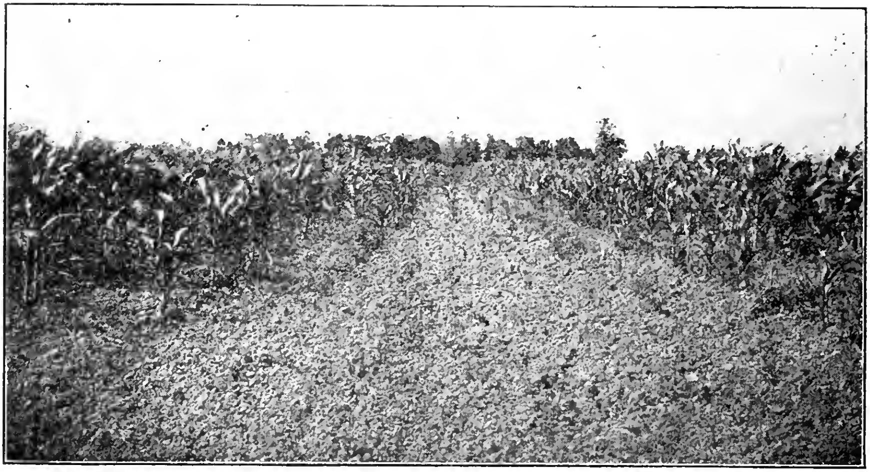


Fig. 4.—There is much land that does not produce crops, owing to the frequency of the surface drains that are formed by means of the plow.

COMPOSITION OF THE CLAY LOAM

Nitrogen and Organic Matter. The clay loam contains a large amount of organic matter as is evidenced by the black color of the soil. Analyses show from 9.19 per cent to 9.73 per cent of volatile matter which corresponds approximately to organic matter. This is due to the swampy condition in which these areas existed for many years thus allowing heavy growths of vegetation to return to the soil. The nitrogen content corresponds with the high content of organic matter, analyses showing from 5,800 to 6,416 pounds per acre six inches as compared to 3,000 pounds in average black clay loam soil. The dark green color of the growing crops and the general tendency of small grains to lodge bear witness of the plentiful supply of this element.

Phosphorus. This soil contains a medium amount of phosphorus, analysis showing from 1,600 to 1,780 pounds per acre six inches. This type normally should contain approximately 2,000 pounds of phosphorus per acre. Phosphate fertilizers when applied usually give excellent returns as might be expected. Unlike the element nitrogen, phosphorus can not be drawn from the air by certain crops and stored in the soil but must be added in either manures or fertilizers. Owing to the slight deficiency of this vital element it may be well said that phosphorus is the first limiting element of soil fertility and its supply should be replenished at frequent intervals.

Potassium. The element potassium is much more abundant in soils than either nitrogen or phosphorus, normal soils containing approximately 30,000 pounds of this element in the surface layer. Analyses of the potassium content of the clay loams show variations from 47,290 to 49,660 pounds per acre of surface soil. Potash fertilizers have not given satisfactory results except where sugar beets have been grown which indicates as does the analysis, that this element is well supplied.

Soil Acidity and Liming. Chemical analyses show that the greater part of the subsoils contain carbonates and that the surface soils are alkaline or sweet in reaction. Excellent crops of clover and alfalfa are being grown

without the use of lime. Applications of lime have been made but no increased yields have resulted. All conditions indicate that an abundant supply of lime is present in this type of soil.

SILT LOAM

Extent of Type. The silt loam is probably first in importance in this area because of its fertility and extent. This type covers approximately 30 per cent of the area and is not confined to any one district but as shown by the map is well distributed throughout the area. The most extensive deposits are in north eastern Lenawee county, northwestern Monroe county and in the extreme southern part of Washtenaw county. Another area of importance is along Lake Erie and the Detroit river.

Topography and Variations in Type. The topography of this type is from level to undulating. Where the old shore lines occur there are ridges which should be classed as rolling, however, these cover only a very small part of these areas and are scarcely worthy of mention.

Fig. 7.—Alsike clover does well on the heavy land.

The level land is composed of a heavy phase of silt loam. The undulating districts are more variable, the knolls being typical silt loam, while the draws and pockets range from clay loam to heavy silt loam. The latter type is high in organic matter and quite friable. The old shore line ridges are sandy in nature varying from a gravelly sand to heavy sandy loam.

Description. The surface soil is composed of a heavy phase of dark colored silt loam containing a high content of organic matter which renders it quite friable. The depth on the knolls ranges from 4 to 6 inches, on the level land 8 inches, while in the draws and pockets it is much deeper, ranging from 10 to 20 inches.

The subsoil is a yellowish brown tight clay to a depth of 18 to 20 inches. Grayish brown mottling is quite prominent in this stratum. Below 20 inches occurs a quite impervious yellow clay except in the lower lands where the

subsoil is grayish blue in color. A more uniform subsoil than that which occurs under this soil is seldom found.

The subsoil of the old shore line ridges is generally gravelly. Several gravel pockets, shallow in depth, furnish considerable material for road ballast.

Drainage. This type of soil has a good natural drainage system so far as the main drain channels are concerned, yet drainage is one of the first limiting factors to most successful agricultural practices. The majority of the drains are open surface ditches although tile are rapidly replacing them in most communities. The excessive amount of waste land, caused by open surface drains, can be put under cultivation when tile are used and thus compensate in part for the excessive cost of tile draining. The digging of the greater part of the channels for tile drains by ditching machines has also reduced somewhat the cost of installing. Lateral tile drains usually should be placed 4 rods apart for best results with this soil.

COMPOSITION

Nitrogen and Organic Matter. The organic matter content is good being only slightly lower than that of the clay loam. Analyses show an average of nine per cent of volatile matter, which indicates the relative amount of organic matter contained.

The nitrogen content of this soil is quite high, analyses showing an average of 5,638 pounds in the surface layers. Crop conditions point toward a sufficient supply of this element for the present especially if clover is grown once in a four year rotation and residues and manure are returned to the soil.

Phosphorus. The phosphorous content is not great. Analyses show an average of 1,456 pounds per acre in the surface layers compared to 1,800 or 2,000 pounds which this type of soil should normally carry. Since phosphorus is an essential element in the formation of the seeds of plants and since the silt loam areas are devoted mainly to grain growing, it can be truthfully said, that from the standpoint of soil fertility, phosphorus is the first limiting element.

Potassium is present in relative abundance in this soil, analyses of samples taken from this area showing an average of 45,920 pounds per acre in the surface layer.

Soil Acidity and Liming. The soils of this type, as the analyses show are either alkaline or neutral—conditions commonly known as "sweet." In some cases the surface soil contains traces of carbonates as small fragments of limestone while the subsoils are alkaline in reaction and usually carry carbonates. Crops such as the clovers and alfalfa produce excellent yields on this soil which indicate an abundance of lime. Results obtained from the use of lime have not been profitable.

METHODS OF IMPROVING CLAY LOAM AND THE SILT LOAM SOILS

Tilth. Tillage operations are relatively difficult on clay loam and silt loam soils. The lack of drainage and fineness of texture limit to a certain extent successful cultivation. Early spring plowing when wet has probably been the greatest factor in increasing the already poor tilth. The pasturing of stock on wet land has also puddled large areas which now require excellent methods of management to bring them back to a proper condition of tilth. The rotation of crops and the turning down of organic matter of any nature

combined with the free use of the disc and fall plowing, wherever possible, are very important practices. Soils that are high in organic matter and are not deficient in lime are far less difficult to maintain in a well granulated condition or in good tilth, than are those that are deficient in these.

Fertilization. The chemical composition of these types show an abundant supply of plant-food elements with the exception of phosphorus. Though the supply is abundant it should not be overlooked that the plentiful elements should in no way be wasted but maintained or increased.

Nitrogen. Without doubt the cheapest means of maintaining the supply of nitrogen is by the production of leguminous plants. When such crops are turned back to the land or fed to stock and the residue and manure properly cared for and applied to the soil they may add a large amount of this element.

Fig. 8.—Small grains produce well on the silt loam soils when well drained. The farmsteads usually afford evidence of fertile soils.

Good rotations will include at least one legume every fourth year. The standard rotations for heavy soils are given in figures. When the price of seed is not too great, the sowing of clover with wheat and oats, the same to be turned under in the autumn is good practice. Such systems and the high nitrogen content of these soils make the use of commercial nitrogen unnecessary except in small amounts in some cases to assist in early growth.

Phosphorus. The element phosphorus commonly spoken of as phosphoric acid, the supply of which is somewhat limited in these soils, is contained largely in the seed or grain of crops. Where grain farming is practiced, as it is on these types, we can logically draw the conclusion that large amounts of phosphorus are removed from the soil. It is true some of this valuable element is returned to the soil by means of crop residues and manure but the amount so returned on the average farm is small in comparison with that which is taken away by the crops.* Where barnyard manure is applied

* For suggestions concerning the use of phosphates send for Popular Bulletin 284, Michigan Agricultural Experiment Station.

to the land it should be reinforced with acid phosphate or raw rock phosphate. It is a common practice to distribute the acid phosphate by means of the fertilizer attachment on the grain drill at the time of seeding. If it is applied to each of the grain crops in the rotation the application should range from 100 to 200 pounds per acre. Where it is added to one of the small grains and the tilled crop in a four year rotation 200 to 300 pounds per acre should be distributed. Where raw rock phosphate is made use of as a carrier of phosphoric acid it may be applied just previous to or following the distribution of the manure and turned under. An application of 1,500 pounds per acre should endure 6 years.

Our fertilizer tests with sugar beets thus far show that phosphoric acid increases the yields more by far than other elements of plant-food. Thus if complete fertilizers are used they should carry a high per cent of phosphoric acid and a small amount of nitrogen and potash. The use of the latter should be looked upon primarily as stimulation of early growth and root development inasmuch as the soils are abundantly supplied with these elements. If acid phosphate is used alone, and in many cases this is the best fertilizer, 200 to 400 pounds should be broadcasted per acre. If the phosphate is applied in the row the quantities should be much less.

Potassium. The element potassium or potash is largely contained in the stems of plants. Under the ordinary methods of farming a greater part of the stalk and straw is returned to the land and consequently the loss of potash is not great. The supply in the soil being abundant this problem is of minor importance for most crops. Yet the popularity of fertilizers high in potash for sugar beets suggest that this should be considered in the production of this crop.

Good tillage practices, the growing of legumes in the rotation and turning back crop residues, through use of reinforced manures and the judicious use of fertilizers means the successful management of these types of soil.

Land Values. The soil comprising the clay loam and silt loam districts of this area compare favorably in fertility with the best in the United States and in productivity with the fertile lands of the corn belt of the west and south, yet the price of these fine textured or heavy lands is low when all conditions are considered. In some regions of the corn belt, land of no greater fertility and not so favorably located is disposed of for much higher prices than the selling values of land in the Detroit area.

SANDY SOILS

Extent. The brown sandy soils are the most extensive on the area, covering approximately 40 per cent of it. They are moreover, well distributed throughout the entire area. The central part of Wayne county and the southern half of Monroe county are practically all sand and comprise two of the largest sandy districts in the area. Seneca, Deerfield and Blissfield townships contain the greater part of the sand in Lenawee county.

Topography and Variations in Type. The topography of the sands varies from gently undulating to slightly rolling. Occasionally relatively level districts of narrow expanse are encountered. Considerable variations in

texture occur. The ridges are usually composed of light sand. Typical medium sandy soil makes up the undulating land, which contains sufficient organic matter and fine soil particles to prevent blowing. In the draws and low situations the texture is somewhat finer ranging from heavy medium sand to typical sandy loams with very high contents of organic matter. Occasionally in the swails the surface soil has been washed away and the heavy clay subsoil is exposed.

DESCRIPTION

Light Sand. This soil is found on the ridges and is commonly spoken of as blow sand. It is rather limited in extent and for the most part is covered with vegetation which holds the sand in place. The surface 10 inches varies from a yellow to yellowish brown medium sand, containing only a very small amount of fine material. The organic matter content is exceedingly low. The subsoil has the same texture as the surface soil, is only slightly lighter in color and varies in depth from 3 to 30 feet. This sand rests upon the impervious clay subsoil so typical of the lake bed area.

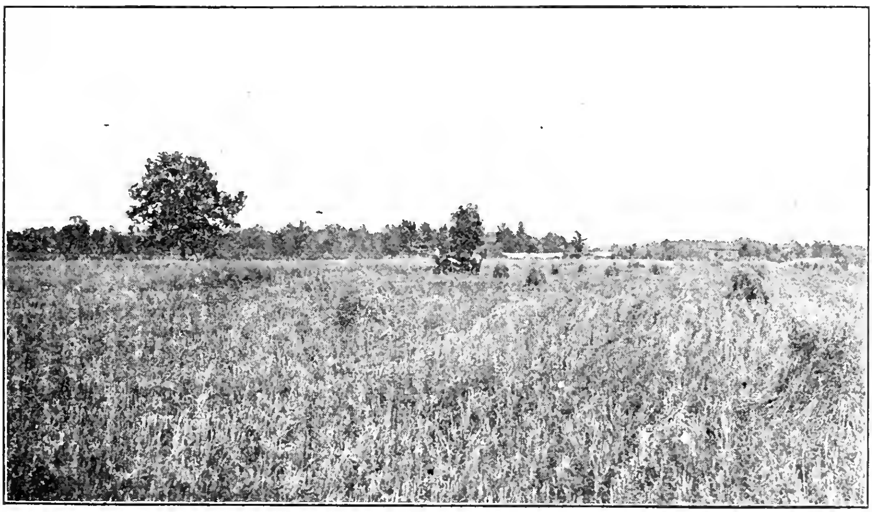


Fig. 9.—The light sand soils are not very productive; especially is this true where the water level lies too near the surface. Drainage and fertilization are needed.

Typical Sand. This soil is quite extensive and furnishes the best agricultural land in the sandy districts. The surface soil to a depth of ten inches is a medium sand ranging in color from a dark yellow to light brown. It contains a high per cent of fine material for a medium sandy soil, yet the organic matter content is high enough to furnish typical sandy structure. The subsoil is composed of sand somewhat lighter in color than the surface and contains more fine soil particles. It varies in depth from only a few inches to about 12 feet and is underlaid by impervious clay subsoil. In some places the cláy lies within 18 inches of the surface and in such cases it impedes drainage.

Heavy Sand. This soil is not extensive being found in the lowlands and swails. The surface is usually a sand or a light phase of sandy loam, containing a high content of organic matter. The subsoil usually consists of a few inches of sand resting on the tight subsoil.

Drainage. Where the clay subsoil is within two feet of the surface the drainage problem is just as complex as in the heavy land. On the ridges and where the clay subsoil is below 24 inches drainage is not a difficult problem. Outlets and natural drainage are well established but field drains are not common. The greater part of the field drains are open surface ditches. The cost of installing tile drains is practically as great as in the heavier lands and the returns from such land are usually smaller, as a result the constructing of permanent drains has not been extensive. While surface drains carry away considerable water during the wet season they afford rather inefficient means of drainage. Field results show that tile drains are the most effective when properly installed and where the clay is near the surface, laterals should be placed from 4 to 6 rods apart for best results.

Fig. 10.—Plowing heavy land when wet results in poor tilth. Careful attention to the water content of these soils when plowed or trampled by livestock is essential to their most successful management.

Soil Acidity. The light type of sand comprising the ridges is deficient in lime and where applications of it have been made excellent results have been obtained especially from leguminous crops.

The typical type of sand for the most part contains more lime than the above —this being especially true where the tight subsoil lies near the surface. Where 8 to 10 feet of sand overlies the clay the surface soils usually show a slight acid reaction.

The heavy type of sand is usually alkaline or neutral in reaction and the need of lime is not general.

Nitrogen. The nitrogen content of the light type of sand is quite low. In most instances it is less than 1,400 pounds per acre in the surface layer. The typical type of sandy soil carries somewhat more of this element of plant-food, the average being about 1,835 pounds, whereas the heavy type of sand which lies in the depressions and swails contains larger quantities, the amount present being quite variable.

Phosphorus. The phosphorus situation is rather critical. The chemical analyses reveal that all these are deficient in this element and the average was found to be 1,091 pounds per acre of the surface soil.

Potassium. The total potassium content of these soils is good. In fact it compares favorably with the finer textured or heavier soils of the area. Where the vegetable matter is low and stable manure is not available in adequate amounts the use of commercial potash should be profitable.

Cropping Systems. The vegetable matter content of these soils should be increased. The most successfully managed are those upon which three year rotations, including a leguminous crop, are practiced, the crop residues and stable manure being properly cared for and returned to the land. A tilled crop and a small grain crop are grown in the rotation. In some cases the rotation is extended one year by growing a mixed meadow. Such practices supply the major portion of the nitrogen that is required in crop production and thus cut down the expenditure for fertilizers. Where drainage is adequate alfalfa may be grown successfully provided the soils are limed and properly fertilized.

The Lime Situation. The practice of liming should be more general. It is needed for the successful production of clovers and alfalfa and increases the yields of small grains except on some of the fields that are composed of heavy or low lying sand. The lime requirement of these lands ranges from about 1,500 pounds to two tons per acre of finely ground limestone. Where alfalfa is to be grown on the deep sands not less than two tons should be applied. If the clay lies near the surface, smaller applications of lime may suffice, inasmuch as the alfalfa roots reach the clay which is high in lime. (For further information on liming soils send for Bulletin No. 91 of the Michigan Agricultural Experiment Station.)

Nitrogen. There is a general need for nitrogen on the sandy lands except those that run high in vegetable matter. Where unmixed fertilizers are purchased nitrogen should be used as nitrate of soda on all crops in the rotation except the legumes. Where rye or wheat is grown early spring top dressings consisting of fifty or more pounds per acre should be made with profit, unless ample amounts of manure are applied in the rotation. If clover is grown every third year it is probable that the size of the application of the nitrate should be reduced. If the rotation is lengthened to four years the timothy should also receive a top dressing.

Phosphates should be added regularly and where the unmixed goods are made use of about two hundred pounds of 16 per cent acid phosphate or an equivalent amount of phosphorus in double superphosphate should be applied to the grain crops in a three year rotation. If a four year rotation is practiced an additional application should be made.

Potash should be applied to the soil just before being devoted to those crops that respond most vigorously to it. Our fertility tests in southern Michigan show that clover is responsive to applications of potash. When grown on infertile sandy soils, potatoes and corn are usually considered to be favorably affected by the addition of it. When the prices are not exhorbitant from 50 to 100 pounds may be applied per acre unless an abundance of manure is used or the soil is well supplied with actively decaying vegetable matter.

It is advisable to use high grade goods if mixed fertilizers are applied. Mixtures for these soils should carry 2 to 4 per cent of nitrogen, 10 to 12 per cent phosphoric acid and about 2 to 4 per cent of potash. These should be applied at the rate of 200 or more pounds per acre.

Land Values. While these soils are for the most part poor the selling price per acre is not far below that of the heavier and more productive ones. This type of soil has been made use of to a large extent by speculators who have charged excessive prices per acre, which accounts for the high valuation.

SANDY LOAM

Extent of Type. This type covers approximately 15 per cent of the area. It occurs as delta formations where the larger streams flowed into the old lake, in the extreme northern part of the district on the lake bed and along the upland. The most prominent deposits of the former are where the Huron, Raisen, Saline and Rouge rivers enter the area.

Topography and Variations in Type. The topography for the most part is gently undulating to rolling. The old delta formations are usually gently undulating with a gradual slope toward the lower land. This type in the old lake bed proper is undulating to rolling.

Throughout the occurrence of the sandy loam as mapped, there are a number of variations from the predominating type. The delta formations are typical in texture, with the exception of coarse particles or small stones which have been thoroughly mixed with the soil. This type in the old lake bed proper is quite variable. Small areas of both lowlands and uplands are sand. Ridges, small in extent, which are common throughout this district are also of the sandy class. Some heavy soils exist in the very low situations but the deposits are too small to be considered in a general map.

SANDY LOAM ON DELTA FORMATIONS

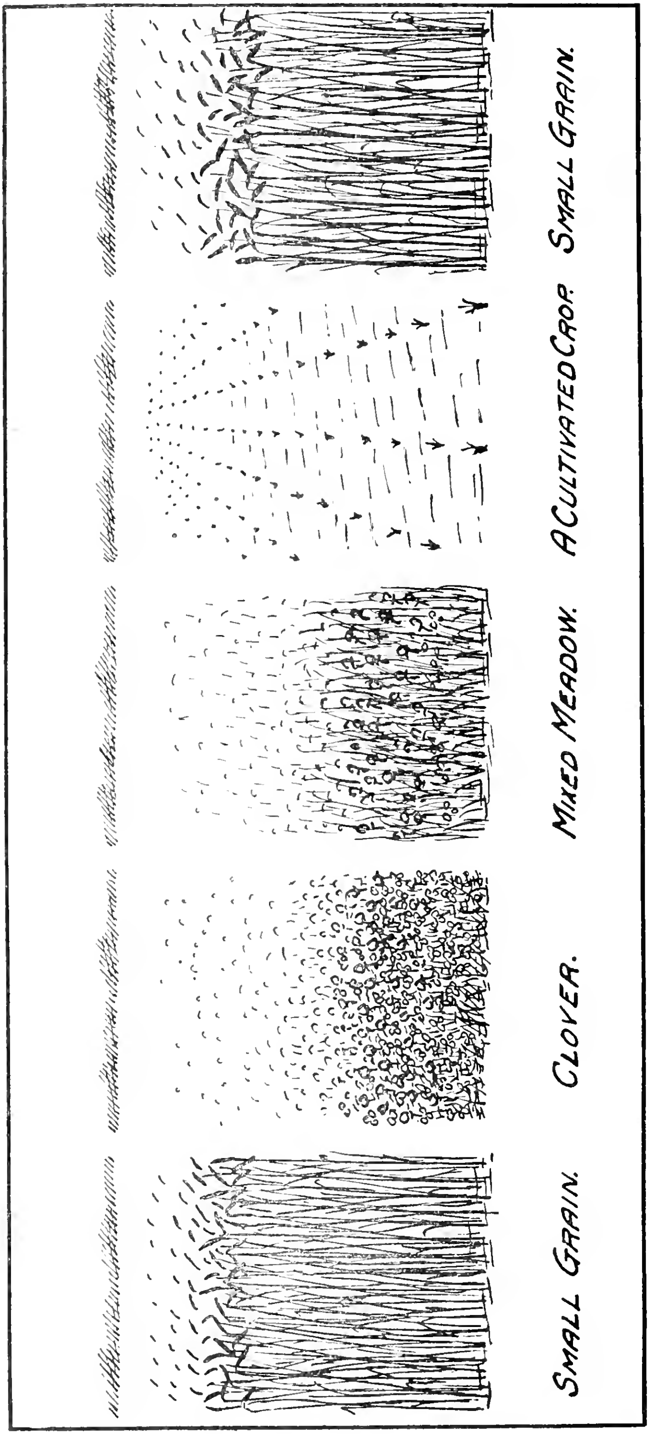
Description. The surface soil ranges from 4 to 12 inches in depth and is a typical sandy loam, light brown to dark grayish in color and is loose, friable and well drained. It contains a large number of small stones near the upland, the number gradually diminishing as the lower lands are approached. The type grades into a heavy phase near the low lands, however, the extent of this heavy phase if very small.

The subsoil is quite variable in texture, but for the most part it contains sufficient amounts of the different soil separates to be loamy in nature. The heavy subsoil so characteristic of this region is so far removed from the surface that it does not effect the surface layers. In general the subsoil of this formation can be classified as one ideal for an agricultural region.

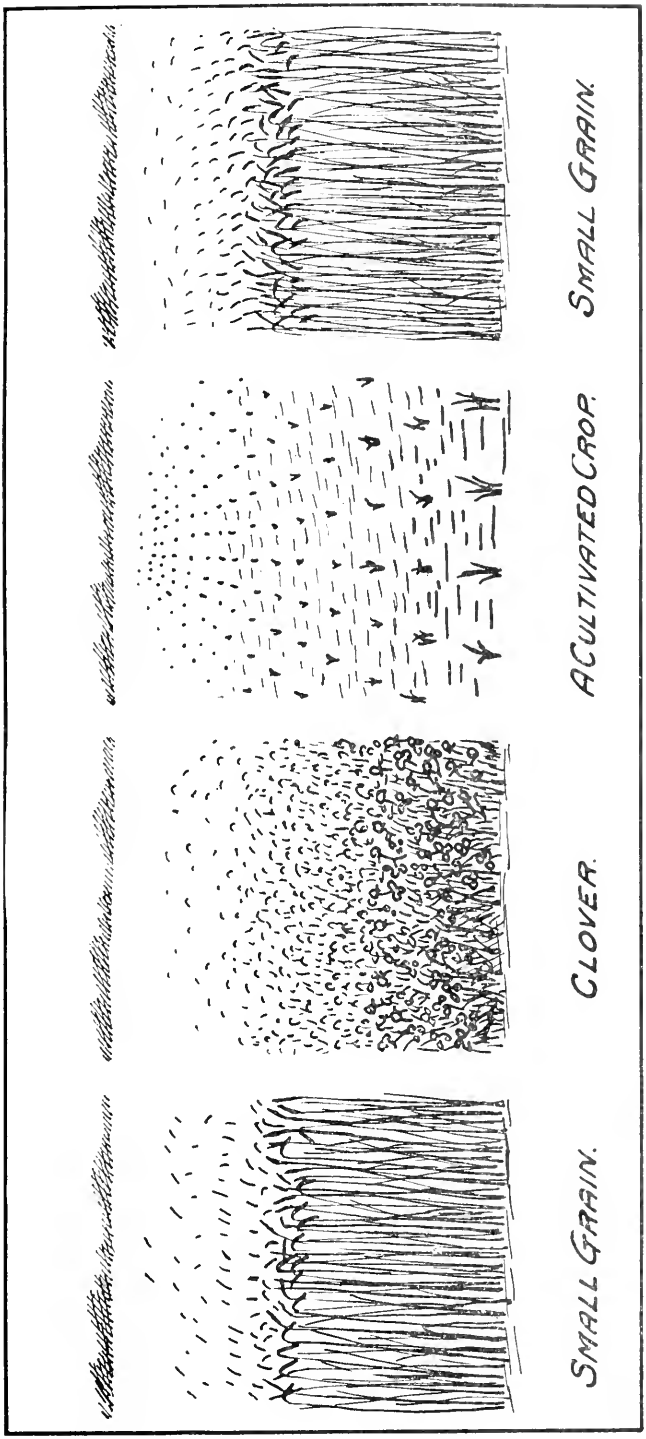
Composition. This type affords a very productive soil, however, little general farming is carried on here, the principal occupation being truck farming. The organic matter and nitrogen content are high, nevertheless large amounts of nitrogenous fertilizers are used. Phosphorus is the most deficient of any of the elements, analyses showing less than 800 pounds per acre in the surface layers. The potassium supply is quite high as is true of practically all of the lake bed soils. This type is fairly well supplied with lime and does not require its application for satisfactory results.

Fertilization. In as much as truck farming predominates on these soils, their fertilization involves heavy cash crops. Where stable manure is used freely the need for both nitrogen and potash is not so great as it is where such is not the case. The liberal use of acid phosphate together with the manure and small amounts of immediately available nitrogen for early cash crops should take care of the fertilization of these soils. Vegetable growers in some sections are using less manure and larger quantities of mixed fertilizers and growing catch crops for green manuring purposes.

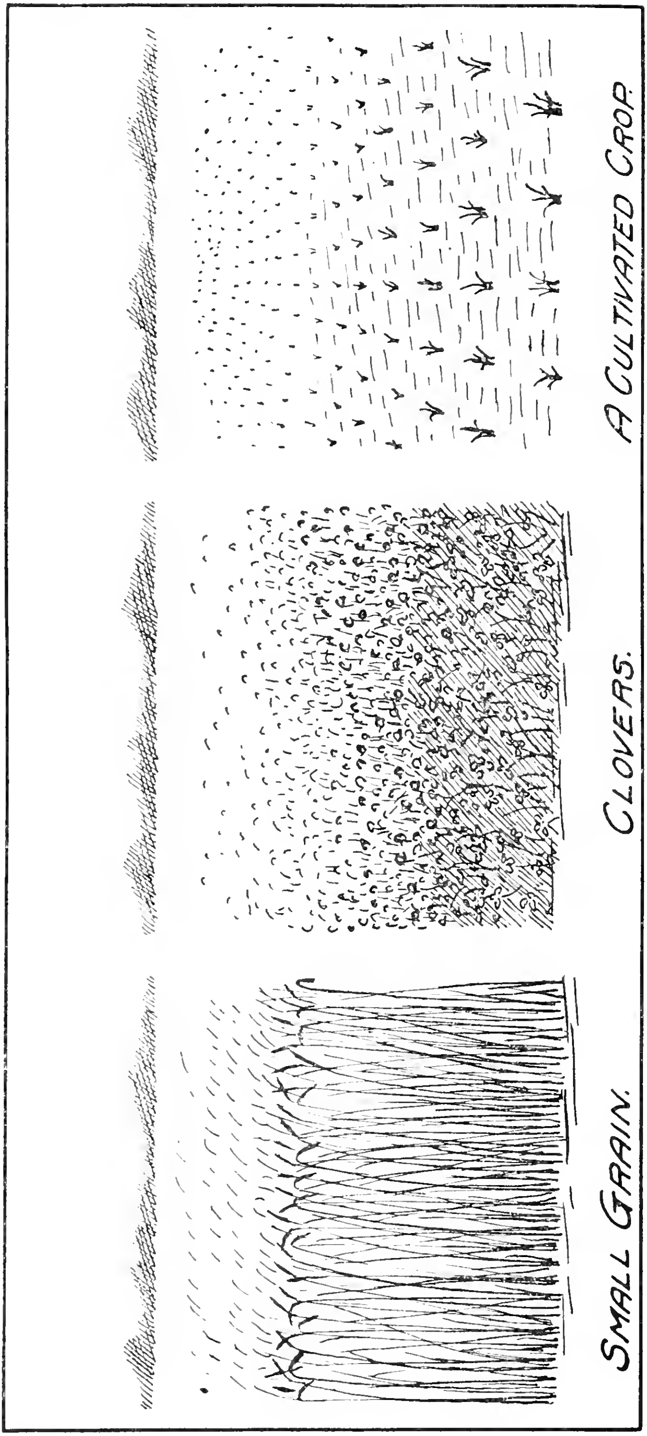
Fig. 13.—Truck crops do well on the sandy lands that were deposited by streams as their deltas.



A FIVE YEAR ROTATION FOR HEAVY SOIL.



A FOUR YEAR ROTATION FOR HEAVY SOIL.



A Three Year Rotation For Sandy Soil.

SANDY LOAM ON OLD LAKE BED

Description. The surface soil to depths of 8 to 12 inches is a black sandy loam containing a high content of organic matter. The fine sand content is quite high making the type a light phase.

The subsoil, immediately under the surface, is composed of fine sand, grayish in color, to the depth of about 24 inches where it gradually grades into a heavier phase, containing a high content of silt and clay. The heavy clay subsoil varies from 4 to 8 feet in depth from the surface.

Drainage. The natural drainage of the delta formations is ideal requiring practically no artificial drains but the natural drainage on the lake bed formation is very poor, the tight subsoil coming near enough to the surface to hold the water. Tile drains are not extensively used because of the poor outlets. A greater part of this land is laid out in lots as suburbs of Detroit and agriculture is not practiced to any great extent.

Composition. From the standpoint of soil fertility this soil is practically the same as the type in the delta formation, with the exception of a slightly lower phosphorus content. While this is usually classed as a poorer soil than the delta formation the difference is due principally to the lack of drainage rather than to the composition. Lime is not needed on these soils.

Fertilization. The management from the fertility standpoint is rather difficult. The phosphorus content must be built up for best results and the organic matter content maintained. By means of manures, which can be obtained from near by cities, and by the liberal use of high phosphate bearing fertilizers this land can be kept in a high state of fertility which is necessary for successful truck gardening.

FINE SANDY LOAM

This type is very small in extent covering only about 3 per cent of the area. Most of the city of Detroit is located on it, and from the standpoint of agriculture it is relatively unimportant.

The topography is level to undulating and wide variations of type follow the different topographic changes. The low lands classify as a heavy phase of sandy loam while the ridges vary in texture from blow sand to clay.

The surface soil to the depth of 8 inches is a black sandy loam quite high in organic matter and containing a high content of fine and very fine sand. From 8 to 36 inches, the subsoil is a yellow fine sand, beneath which the more impervious layer of clay is encountered.

Drainage on this type for the most part is quite poor. Where there is land available for agricultural purposes it is generally so poorly drained that pasture or hay crops are all that are being grown. Outlets are established but the land is plotted to building lots and little is being done in an agricultural way.

This soil is only medium in fertility. It is quite well supplied with organic matter, nitrogen and potassium but phosphorus and lime are needed. Analyses show the surface layer to contain as an average 916 pounds of phosphorus and to be acid in reaction. For the city garden complete fertilizers carrying from 3 to 4 per cent of nitrogen, 8 to 12 per cent of phosphoric acid and 2 to 3 per cent of potash should be used at the rates of 300 to 1,000 pounds per acre. They should be worked into the soil just previous to seeding or planting, to a depth of about three inches.

SANDY LOAM ON GRAVELLY SUBSOIL

Another sandy loam quite small in extent covering less than 1 per cent of the area. It comprises a terrace formation or second bottom land and is located in Ypsilanti township in Washtenaw county and Van Buren township in Wayne county, extending along the flood plains of the Huron river.

The topography is level to undulating which is characteristic of such formations. The texture is quite uniform, practically no soil type changes are encountered.

The surface soil ranges in depth from 7 to 10 inches and is a light brown typical sandy loam. In some localities gravel stones are quite common in the surface layers, however, their presence does not result unfavorably.

The subsoil to the depth of 28 inches is a yellow to gray sandy silt containing a few gravel stones. Below 28 inches the subsoil grades into a loose sandy gravel grayish in color. A more ideal subsoil could not be obtained. The sandy silt layer nearest the surface is sufficiently deep and impervious to prevent rapid percolation of water yet porous enough to furnish good drainage.

Soil Composition. This sandy loam although very small in extent is productive. The organic matter, nitrogen, potassium and lime contents according to analyses and as indicated by the growth of crops are good. The element phosphorus is deficient, analysis showing an average of 842 pounds in the surface layers.

While the amounts of fertilizing elements in this soil are somewhat lower than the heavy land in this area, crop yields are practically the same and the quality of grain excellent. This can be accounted for by the excellent natural drainage and by good soil management. This district is largely devoted to systematic dairy farming and a large amount of manure which is well taken care of is returned to the land. Phosphoric acid either as the acid phosphate

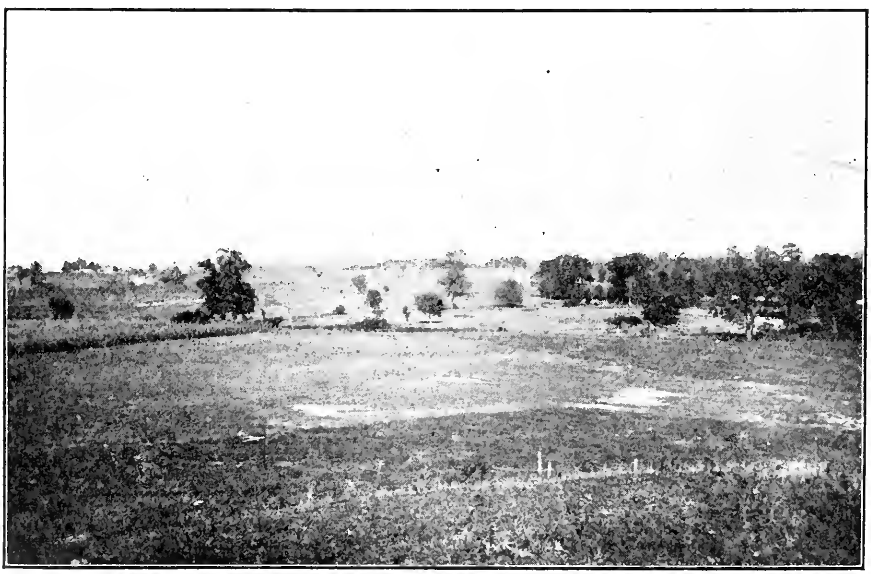


Fig. 14.—The flood plains are used largely as pasture land.

or the raw rock should be used freely on these farms. If the former is made use of 200 pounds or more should be applied per acre twice in a four year rotation, whereas if the latter is used about 1,500 pounds should endure six years.

RIVER FLOOD PLAINS

While no areas have been mapped as flood plains they really are of importance even though they are small in extent. These soils are located along the rivers and their tributaries, and are known as the bottom lands. Such soils afford probably the most fertile lands in the area due to their overflowing each year and soil material being deposited. This overflowing is the controlling factor from the agricultural standpoint. Most of the land is left to pasture, however, some is put under cultivation and late spring crops seeded. The latter is not highly advisable, however, because of the havoc wrought to crops, occasionally in early summer. It seems more advisable to allow the land to stay in pasture and feed live stock as an occupation. It is along the larger streams that dairy farming is quite prominent, large herds being grazed on the flood plain soils while the uplands are used to grow the winter feed.

COMPOSITION OF SOILS OF THE DETROIT AREA

Soil.	Pounds in 2,000,000 pounds of soil.					
	Nitrogen.	Phosphorus.	Potassium.	Calcium.	Sulphur.	Magnesium.
Clay loam	6,108	1,690	49,660	19,600	16,027	9,720
Silt loam	5,638	1,456	45,920	19,960	1,286	10,370
Brown sand	1,835	1,091	22,000	10,360	654	3,500
Sandy loam	3,110	711	26,000	15,160	1,310.7	4,260
Fine sandy loam	3,250	916	34,500	10,980	824	4,860
Sandy loam on gravelly subsoil	2,844	842	28,400	10,740	620.7	4,500

SUMMARY

The Detroit Area is situated in the extreme southeast part of the State of Michigan covering approximately 1,543 square miles. It consists of a small part of the bed of the ancient lake Maumee.

The first settlements were made by the French along the shore of Lake Erie and the Detroit river. Dense growths of timber had to be removed before agricultural operations could be started. Real agriculture dates back to approximately 1818. Development was gradual until in 1875 the greater part of the entire area was cleared. Transportation and good markets accounted for the rapid development.

Detroit and Monroe are the two principal cities with smaller cities scattered over the area. Excellent transportation facilities are offered to the larger cities both by railroad and highway. Water transportation to Cleveland, Buffalo and other eastern markets is easily obtained.

Drainage throughout most of the area is poor. Outlets for the most part are well established but a lack of field drains is the greatest limiting factor to agriculture.

The Climate is quite desirable. The winters are of medium length and not severe and the summers of sufficient length to furnish a good growing season. The normal rainfall is approximately 30 inches and the mean annual temperature 48° F. The average growing season is about 157 days.

The principal crops grown are corn, oats, wheat, barley, hay and potatoes. Diversified farming is carried on to a large extent, while grain and livestock farming and dairying are the two leading interests. Near the cities truck farming is very important.

Livestock. The raising and fattening of hogs and the fattening of cattle and lambs along with dairying are the greatest livestock interests.

The average sized farm is approximately 80 acres. On the heavy lands 75 per cent of the owners operate their farms while on the light soils approximately 90 per cent operate their own farms.

The soil types mapped are clay loam, silt loam, fine sandy loam, brown sand, sandy loam and sandy loam on gravelly subsoil.

The clay loam which comprises about 10 per cent of the area, lies chiefly in the southern part. Although its natural drainage is poor this soil is very productive when drained and carefully managed. The vegetable matter and nitrogen contents are unusually high, the phosphorus runs above 1,600 pounds and the potassium supply ranges from 47,290 to 49,660 pounds per acre of surface soil. Lime is present in suitable amounts. The chief considerations in the successful management of the clay loam soil are drainage, attention to the water content when tilled or plowed or trampled by live stock in order to avoid puddling, a systematic rotation of crops and the use of phosphates. If acid phosphate is applied to each of the grain crops in the rotation the amounts should run from 100 to 200 pounds per acre. If it is added to one of the small grain crops and the tilled crop in a four year rotation 200 to 400 pounds should be distributed. Where raw rock is utilized as a carrier of phosphorus it should be scattered just previous to or following the distribution of manure and turned under.

The brown sands comprise the largest acreage and are the most widely distributed of the soils, covering approximately 40 per cent of the area. There are three divisions that are easily recognized, namely, light sand, typical medium sand and heavy sand. The boundaries of these are not given because their location involves much time and detailed work.

The light sand is commonly spoken of as blow sand. It is deficient in and responds to lime, is low in vegetable matter, nitrogen and phosphorus. Potassium is present in goodly quantities, yet the amount rendered available to crops is not sufficient for satisfactory crop yields.

The typical medium sand is not so deficient in lime as the light sand, has an average nitrogen content of 1835 pounds per acre of surface soil, carries about the same amount of phosphorus and potassium as the light soils.

The heavy type of brown sand as a rule is alkaline or sweet in reaction and the need for lime is not general. The vegetable matter and nitrogen are present in ample quantities, the phosphorus is medium in amount for light soils while the potassium compares favorably with the heavy soils of the area.

The improvement of the less productive brown sands is rather expensive and involves several things. Short rotations or those in which leguminous crops are produced frequently are desirable. Where needed lime should be applied, the lime requirement of the sour sands ranges from 1,500 to 4,000 pounds of finely ground limestone per acre.

Where unmixed fertilizers are made use of nitrate of soda could be applied to advantage to all except the leguminous crops, except where manure is added in suitable amounts and where the soils are high in vegetable matter. Phosphates should be added regularly, 200 pounds of 16 per cent acid phosphate or an equivalent amount of phosphorus in double superphosphate should be added to each of the grain crops in a three year rotation and if this is extended to four years an additional application should be made. When prices of potash are not exhorbitant, that is in comparison with the crops raised, 50 to 100 pounds should be applied to the soils low in vegetable matter and where stable manure is not available.

If mixed fertilizers are utilized they should carry from 2 to 4 per cent of nitrogen, 10 to 12 per cent of phosphoric acid and 2 to 4 per cent of potash. As a rule 200 or more pounds should be applied per acre.

Land speculators are operating constantly in the poorer sandy land districts. As a result their selling prices are not far below those of the heavy lands, which is unfortunate.

The sandy loam soils that were laid down as river deltas are very productive. They are high in native fertility with the exception of phosphorus, usually carrying less than 800 pounds per acre of it in the surface soil. In texture these are ideal soils for truck gardening, to which they are largely devoted. Their successful fertilization involves liberal applications of stable manure, catch crops for green manuring and commercial fertilizers. In some instances the size of application of manure could be decreased and the commercial fertilizers increased to advantage.

The sandy loams on the lake bed proper, are somewhat less productive than the above, due chiefly to improper drainage, rather than to less native fertility. Owing to similarity in texture and composition the fertilization of these should be similar to the sandy loam on the delta formations. The results from fertilizers are disappointing until drainage is adequate.

The fine sandy loam occupies about 3 per cent of the area and owing to the fact that the greater part of the city of Detroit is located on it, agriculture

is relatively unimportant. These soils are usually poorly drained and only medium in fertility. For city gardening commercial fertilizer composed of 3 to 4 per cent of nitrogen, 8 to 12 per cent of phosphoric acid and 2 to 3 per cent of potash should be applied in amounts ranging from 300 to 1,000 pounds per acre. These should be incorporated in the soil to a depth of about three inches just previous to seeding or planting.

The sandy loam on gravelly subsoil although small in extent is very important agriculturally, being devoted chiefly to dairy farming. Aside from phosphorus these soils are well supplied with elements of plant-food. The use of phosphorus in conjunction with the manure produced on these farms is the chief consideration in their fertilization. At least 200 pounds of acid phosphate should be applied twice in a four year rotation and if raw rock is utilized as a carrier of phosphorus 1,500 pounds should be applied per acre and endure about 6 years.

The river flood plains are exceptionally fertile but owing to the overflowing of the streams they are devoted chiefly to grazing.

The silt loam is the second largest in extent covering 30 per cent of this area. Its occurrence is not confined to any one locality but well distributed. Its natural drainage is poor yet when this condition is attended to this is a very productive soil. It compares favorably with the clay loam in native fertility, containing about the same amount of vegetable matter and nitrogen, somewhat less phoshporus, more potassium and carries enough lime to be alkaline or sweet in reaction. The principles set forth in the discussion of the management of the clay loam soils in general apply to the silt loams of this area.

During the last regular session of the legislature the bill (Act 12, P. A. 1921) creating the Department of Agriculture was passed. By a provision of this bill the inspection of commercial fertilizers will, on and after July 1st, 1921, be conducted under the direction of the Department of Agriculture. All communications in regard to licensing or inspection and analysis of commercial fertilizers should, after the above mentioned date, be directed to the Commissioner of Agriculture, Lansing, Michigan.

FERTILIZER ANALYSES

Regular Bulletin No. 291

BY ANDREW J. PATTEN, O. B. WINTER, M. L. GRETTENBERGER AND P. O'MEARA—
CHEMICAL SECTION

This bulletin contains the results of the inspection of commercial fertilizers for the year 1920 and the spring season of 1921. The analyses and discussion of the results are given separately for the two years.

The fertilizer inspection has been conducted by the Experiment Station since 1885 when the first law, regulating the sale and distribution of commercial fertilizers in Michigan, was passed. The first inspection bulletin was published in 1886 by the late Dr. R. C. Kedzie. That bulletin contained the analyses of only 15 samples. Since then an inspection bulletin has been published annually with the exception of two years, making a total of 34 bulletins including the current issue. The number of samples analyzed during the year has increased to over 1000.

During the time that the fertilizer inspection has been conducted by the Experiment Station only one case has been prosecuted and that was against a local dealer who sold a carload of ground limestone representing it to be a mixture of rock phosphate and ground limestone. The details of this case are given in Bulletin No. 283. It has been our experience that the publicity given the results through the distribution of the annual fertilizer bulletin is a far greater and more potent force in the prevention of fraud than any amount of fines that might be imposed by the courts.

In 1914 we first published results showing the quality of the nitrogen used in mixed fertilizers. This has been continued since that time and, as a result, there has been a gradual and steady improvement in the quality of the nitrogen. One may now be reasonably sure of getting nitrogen of good quality in practically all of the higher grade fertilizers. This is not so true of the low grade mixtures, which fact constitutes one of the chief arguments against buying such fertilizers. In this connection it is gratifying to note that the National Fertilizer Association, at their recent meeting, unanimously went on record as favoring high analysis fertilizers.

The actual consumption of commercial fertilizers during the earlier years is not known, but was, of course, very small. During the year 1906, when the first attempt was made to determine the fertilizer consumption it was estimated at 20,000 tons. This has steadily increased until last year, 1920, when, based upon reports received from the manufacturers, it reached the high point of 112,616 tons. The distribution of this amount throughout the State is shown in the following table:

REPORTED FERTILIZER SALES, BY COUNTIES, FOR SEASON 1920.

County.	Spring.	Fall.	Total.
Alcona	15	....	15
Allegan	1063½	1370	2433½
Alpena	176	....	176
Antrim	118½	59	177
Arenac	64	....	64
Barry	342½	522	864½
Bay	1033¼	328	1361¼
Benzie	¼	....	¼
Berrien	1386½	1658	3044½
Branch	378½	516	894½
Calhoun	310½	350¼	660¾
Cass	127¼	149	276¼
Charlevoix	267	107	374
Cheboygan	44½	....	44½
Clare	40	31	71
Clinton	653	2315	2968
Crawford	2	....	2
Eaton	1482	2488¾	3970¾
Emmet	159	68	227
Genesee	2554¼	2674	5228¼
Gladwin	109	53	162
Grand Traverse	113½	41	154½
Gratiot	1772	1554	3326
Hillsdale	1059¾	1361	2420¾
Huron	1593	2275¼	3868¼
Ingham	892	1029	1921
Ionia	708	1974¾	2682¾
Iosco	131	....	131
Isabella	628	240	868
Jackson	451	222	673
Kalamazoo	1236	644	1880
Kalkaska	24½	....	24½
Kent	1497½	1793	3290½
Lake	4	....	4
Lapeer	1611	1605	3216
Leelanau	291	118	409
Lenawee	2885½	1653½	4539
Livingston	305¼	230	535¼
Macomb	3033¾	2779	5812¾
Manistee	19	....	19
Mason	102¼	30	132¼
Mecosta	38	21	59
Midland	107	50	157
Missaukee	86	....	86
Monroe	2808	2614½	5422½
Montcalm	628	840	1468
Montmorency	12	....	12
Muskegon	332¾	383¼	716
Newaygo	294½	90	384½
Oakland	1154½	1058	2212½
Oceana	264½	144	408½
Ogemaw	19	30½	49½
Osceola	91	75	166
Oscoda	16	....	16
Otsego	20¾	¼	21

REPORTED FERTILIZER SALES, BY COUNTIES, FOR SEASON 1920—*Continued.*

County.	Spring.	Fall.	Total.
Ottawa	2734	2878	5612
Presque Isle	121	53	174
Roscommon	....	....	....
St. Clair	2682	2716	5398
St. Joseph	129¼	100	229¼
Saginaw	1985½	2107½	4093
Sanilac	2851	3200½	6051½
Shiawassee	961½	1794½	2756
Tuscoia	3723¾	2397¼	6121
Van Buren	885¼	882	1707¼
Washtenaw	1715¼	2225	3940¼
Wayne	2691¼	2077	4768¼
Wexford	53	169	222
Alger	....	....	....
Baraga	....	....	....
Chippewa	3	....	3
Delta	41¾	....	41¾
Dickinson	18	....	18
Gogebic	15	....	15
Houghton	35¼	....	35¼
Iron	....	....	....
Keweenaw	....	....	....
Luce	16	....	16
Mackinac	8	½	8½
Marquette	64	....	64
Menominee	986½	15	1001½
Ontonagon	....	....	....
Schoolcraft	239	....	239
	57,515¾	55,100¼	112,616

LICENSED BRANDS.

During the year, 1920, 37 manufacturers and fertilizer companies licensed 426 brands for sale in Michigan. One new company, The Southern Fertilizer and Chemical Company, registered 20 brands during the fall season. Of this number, however, 12 were not shipped into the State. The U. S. Gypsum Company, Chicago, Ill., and the R. H. Hoover Laboratories, Inc., Freeport, Ill., licensed "Ben Franklin Agricultural Gypsum" and "Plant-life" respectively, after the regular fertilizer season had closed. No samples of either brands have been found on the markets and they are not included in the tables of analyses.

Attention is called to the fact that the fertilizer law covers only those materials which are sold, offered or exposed for sale within the State, the retail price of which is $10.00 or more per ton. Manufacturers residing outside the State may ship direct to the consumer without paying the license fee but the party making the purchase receives no protection under the law. If the sale of fertilizer to be shipped direct to the consumer is made by an agent or representative of the manufacturer while in the State, the act is considered as one of actually offering the material itself for sale, and the fertilizer then becomes subject to the requirements of the law just as surely as though the fertilizer were actually brought into the State and then sold. Consequently, an agent of a fertilizer company is technically violating the law when he solicits or accepts orders for any unlicensed fertilizer, while in the State.

COLLECTION OF SAMPLES.

The collection of samples was made during the spring and fall shipping seasons by inspectors appointed by the State Board of Agriculture.

All sections of the State in which fertilizers are used to any extent were visited, and 907 samples were secured from stocks being offered for sale by dealers. For this purpose a specially constructed tube is used, which permits of securing a core from the entire length of the bag. An official sample consists of the cores taken from not less than ten separate sacks of the same brand. The ten or more separate cores are mixed together, placed in a stout sack, tied, sealed and forwarded to the laboratory for analysis.

During the year 71 registered brands were not shipped into the State. It was formerly the custom, whenever we failed to find a brand on the market, to analyze the sample forwarded by the manufacturer, as required by law, at the time of applying for the license. It has long been known that these samples were generally, if not always, made up in the laboratories of the companies and were not, therefore, representative of the product as put on the market. For this and other reasons we have discontinued this practice and in this bulletin the brands not represented by samples are listed in their proper places but are not given a laboratory number and only the guaranteed analysis is shown.

In many cases several samples of the same brand were drawn and analyzed. This, of course, greatly increases the work in the laboratory but it is the only way by which we can ascertain if the brands are running uniform. If only one sample were analyzed, or if several samples were taken and composited before being analyzed, variations in the composition would not be detected.

RESULTS OF INSPECTION.

Of the 907 samples analyzed representing 355 brands, 255 (27.1%) were found to be below guarantee* in one or more ingredient. Sixty-four (7.1%) were below guarantee in nitrogen, 2 (0.2%) were below guarantee in total phosphoric acid, 75 (8.3%) were below guarantee in available phosphoric acid and 150 (16.5%) in potash. This is a slight increase in the number of deficiencies, compared with 1919 and a considerable increase when compared to the results obtained for several years prior to 1919. This increase in the number of samples found below guarantee is undoubtedly due, in part at least, to the fact that during the war the fertilizer market was badly upset, and has not yet returned to normal. However, this does not absolve the manufacturer who consistently, year after year, has about the same number of samples falling below guarantee.

There is no provision in the fertilizer law for the payment of rebates on fertilizer shipments found to be below guarantee, but the manufacturer demonstrates his good will when he voluntarily takes care of such cases as they are called to his attention. In many cases a fertilizer is found to be below guarantee in one ingredient and to overrun the guarantee in some other ingredient sufficiently so that the actual value is not really lowered. This condition indicates imperfect mixing, or a lack of proper factory control, and while the purchaser is not defrauded from a financial standpoint he still does not get what he contracted for and what he has a right to expect.

In the following table a summary of the results of the inspection is given This shows at a glance, the number of brands licensed by each company, the number of samples analyzed and the number falling below guarantee in one or more ingredient. In the last column is given the number of samples whose value has been found to be $1.00 or more per ton less than that guaranteed. A careful study of this table as well as the detailed results of analysis which follow should be made by all persons who intend to purchase fertilizers for the coming season.

*A shortage of more than 0.10 per cent. of nitrogen or more than 0.20 per cent. available phosphoric acid or more than 0.10 per cent. potash is considered below guarantee.

Manufacturer.	No. of brands licensed.	No. of samples analyzed.	No. below guarantee in one or more ingredient.	No. below value guaranteed.
American Agricultural Chemical Co.	101	186	7	1
Armour Fertilizer Works	29	57	19	11
The Barrett Company	1	3	0	0
R. Binder Company	1	1	0	0
N. Burleson	1	2	0	0
E. Burton Fertilizer Works	1	1	1	1
Calumet Fertilizer Company	22	50	19	3
Chicago Feed & Fertilizer Company	1	0	0	0
Columbia Guano Company	17	18	4	2
Darling & Company	12	44	6	0
Federal Chemical Company	28	66	21	11
Fertile Chemical Company	2	0	0	0
Gleaner Clearing House Association	9	13	5	0
International Agricultural Corporation	29	64	20	4
Jarecki Chemical Company	10	27	14	5
Natural Guano Company	1	0	0	0
Nitrate Agencies Company	1	0	0	0
Pacific Manure & Fertilizer Company	1	2	2	2
Parke, Davis & Company	1	0	0	0
Packers Fertilizer Company	9	19	9	3
Pulverized Manure Company	4	5	0	0
Queen City Fertilizer Company	1	0	0	0
Rasin Monumental Company	15	7	0	0
Read Phosphate Company	1	1	1	0
F. S. Royster Guano Company	20	78	28	11
Smith Agricultural Company	10	24	9	2
Sodus Humus Company	1	1	1	1
Southern Fertilizer & Chemical Company	20	26	13	6
J. L. & H. Stadler Rend. & Fert. Company	11	22	5	1
H. Stewart & Sons	1	1	1	0
Swift & Company	26	73	28	13
Tennessee Coal Iron & Railraod Company	1	0	0	0
Virginia-Carolina Chemical Company	18	42	3	1
The Welch Chemical Company	13	50	24	9
Wing & Evans	1	2	0	0
Wulchet Fertilizer Company	5	22	15	3
Witherbee, Sherman & Company	1	0	0	0
	426	907	255	89

EXPLANATION OF TABLES.

The results of analysis shown in the following tables are arranged by manufacturers, in alphabetical order. Those found below guarantee are printed in bold face type.

Nitrogen—It will be noted that the results under this heading are divided into four columns. The column headed "As Soluble" shows the amount of nitrogen that is soluble in water. This would include all nitrogen present as nitrate of soda, sulfate of ammonia, cyanimid, etc. This portion of the nitrogen is considered to be immediately available.

The second and third columns together represent the nitrogen that is insoluble in water. This insoluble nitrogen is separated into "active" and "inactive" nitrogen depending upon its reaction with an alkaline solution of potassium permanganate. When the amount shown "as active insoluble organic" is greater than that shown "as inactive insoluble organic" the whole insoluble nitrogen is considered to be of good quality. In other words, it has been derived from some high grade material possessing a high rate of availability or the material used has been treated in such manner as to render it largely available. If, on the other hand, the amount of nitrogen shown in the "inactive" column is greater than that shown in the "active" column then the *insoluble nitrogen* is considered to be low grade with a low rate of availability. When the insoluble nitrogen constitutes a small percentage of the total, its rate of availability would, of course, be of small consequence. But, where the "insoluble nitrogen" constitutes a considerable portion of the total, as is very often the case, then its rate of availability is an important factor.

Since nitrogen is, by far, the most expensive plant food ingredient in fertilizers, more attention should be given to the results printed in the following pages under this heading and when purchasing nitrogenous fertilizers preference should be given those companies that show the insoluble nitrogen nitrogen in their mixtures to be derived from high grade materials.

The fourth column shows the total amount of nitrogen in the sample. It is equal to the sum of the first three columns.

Phosphoric Acid—Three divisions are included under this heading, designated as "total", "insoluble" and "available." The "total" phosphoric acid includes all of this ingredient in the sample. The "insoluble" phosphoric acid respresents that portion that is unavailable and the "available" phosphoric acid, is, as the name implies, readily available. The available phosphoric acid represents the difference between the total and insoluble phosphoric acid.

Potash—The results shown under this heading are those soluble in water as required by the law. Water soluble potash is, of course, readily available.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	American Agricultural Chemical Co., Detroit, Mich.										
A 4406	A High Grade Garden & Vegetable Fertilizer	Erie	G.†				*1.65*			*8.00*	*5.00*
			F.†	1.16	0.27	0.21	1.64	10.25	0.62	9.63	5.21
A 4439	All Grain Fertilizer	Novi	G.†				*1.65*			*12.00*	*3.00*
			F.†	1.39	0.21	0.11	1.71	13.60	0.68	12.92	3.09
A 4474	Amo-Phos Fertilizer	Highland	G.†				*1.65*			12.00	
			F.†	1.38	0.36	0.10	1.84	15.15	1.24	13.91	
			G.†				*0.82*			*9.00*	*1.00*
A 3975	Beet Fertilizer 1916	Riverdale	F.†	0.65	0.12	0.16	0.93	10.25	1.00	9.25	1.53
A 4331	Beet Fertilizer 1916	Shepardsville		0.73	0.10	0.07	0.90	9.65	0.86	8.79	1.21
		Average		0.69	0.11	0.12	0.92	9.95	0.93	9.02	1.37
A 3868	Climax Complete Fertilizer	Grand Ledge	G.†				*1.65*			*8.00*	*2.00*
			F.†	1.29	0.29	0.22	1.80	10.25	1.24	9.01	2.26
A 4290	Crown Phosphate and Potash	East Lansing	G.†							*8.00*	*2.00*
			F.†					13.85	1.06	12.79	2.00
			G.†							*10.00*	*2.00*
A 4169*	Dissolved Bone Phosphate & Potash	Tyre	F.†					11.10	0.66	10.44	2.23
A 4692*	Dissolved Bone Phosphate & Potash	New Lathrop						11.85	0.72	11.13	2.11
		Average						11.48	0.69	10.79	2.17
			G.†				*0.82*			*8.00*	*2.00*
A 3735	Favorite Potash Fertilizer	Richmond	F.†	0.54	0.09	0.18	0.81	10.25	1.06	9.19	2.09
A 4262	Favorite Potash Fertilizer	Clayton		0.70	0.09	0.12	0.91	10.30	0.74	9.56	2.08
A 4544*	Favorite Potash Fertilizer	Richmond		0.49	0.11	0.23	0.83	10.20	0.94	9.26	2.00
		Average		0.58	0.10	0.17	0.85	10.25	0.91	9.34	2.06
A 4100	Fine Ground Bone	Benton Harbor	G.†				*1.65*	*27.00*			
			F.†	0.74	1.02	0.26	2.02	28.55			

			G.†							*10.00*	*5.00*
A 3867	High Grade Phosphate & Potash	Grand Ledge	F.†					11.35	0.22	11.13	5.22
			G.†				*0.82*			*8.00*	*3.00*
A 4261	M. & I. 3% Potash	Clayton	F.†	0.70	0.09	0.12	0.91	10.15	0.56	9.59	2.96
A 4280	M. & I. 3% Potash	Mason		0.72	0.10	0.12	0.94	9.90	0.80	9.10	3.01
		Average		0.71	0.10	0.12	0.93	10.03	0.68	9.35	2.98
	Michigan Bean Grower 1916		G.†				*1.65*			*8.60*	*1.00*
			G.†				*0.82*			*8.00*	*1.00*
A 3716	New York State Special 1916	Washington	F.†	0.51	0.13	0.29	0.93	10.20	1.30	8.90	1.07
A 3733	New York State Special 1916	Richmond		0.67	0.09	0.19	0.95	10.65	1.60	9.05	1.26
A 4308	New York State Special 1916	Bankers		0.73	0.12	0.03	0.88	10.00	1.00	9.00	1.02
A 4545*	New York State Special 1916	Richmond		0.45	0.17	0.24	0.86	10.00	0.86	9.14	1.11
		Average		0.59	0.13	0.19	0.91	10.21	1.19	9.02	1.12
			G.†				*15.00*				
A 3838	Nitrate of Soda	Fennville	F.†				15.40				
			G.†				*1.65*			*10.00*	
A 4438	Special Nitrophos	Fennville	F.†	1.56	0.19	0.05	1.80	13.15	1.61	11.51	
			G.†				*0.82*			*10.00*	
A 3714	1 and 10 Compound	Washington	F.†	0.50	0.24	0.24	0.98	13.70	1.56	12.14	
A 4298	1 and 10 Compound	Fowlerville		0.51	0.21	0.17	0.92	12.30	1.80	10.50	
		Average		0.52	0.22	0.21	0.95	13.00	1.68	11.32	
	Bradley Brands										
	Acid Phosphate		G.†							*10.00*	
			G.†							*16.00*	
A 4445	16% Acid Phosphate	Ypsilanti	F.†					19.30	0.86	18.44	
			G.†							*10.00*	*2.00*
A 3870	Alkaline Phosphate & Potash	Grand Ledge	F.†					11.75	0.58	11.17	1.97
A 4080	Alkaline Phosphate & Potash	Buchanan						12.05	0.56	11.49	2.05
A 4471	Alkaline Phosphate & Potash	Davison						12.45	0.72	11.73	2.10
		Average						12.08	0.62	11.46	2.01
			G.†				*0.82*			*10.00*	*1.00*
A 3921	All Crops Fertilizer	Lacota	F.†	0.68	0.16	0.15	0.99	12.80	1.30	11.50	1.50
			G.†				*1.65*			*10.00*	
A 3974	Binfiller	Riverdale	F.†	1.41	0.20	0.17	1.78	12.70	1.68	11.02	
A 4490	Binfiller	Detroit		1.34	0.23	0.19	1.76	13.15	1.56	11.59	
		Average		1.38	0.21	0.18	1.77	12.93	1.62	11.31	

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	American Agricultural Chemical Co.—Cont.										
	Bradley Brands.—Cont.										
			G.†				*0.82*			*8.00*	*1.00*
A 3869	Dissolved Bone Phosphate with Potash '16	Grand Ledge	F.†	0.57	0.14	0.13	0.84	9.60	0.92	8.68	1.14
A 4263	Dissolved Bone Phosphate with Potash '16	Clayton		0.70	0.10	0.11	0.91	9.90	1.00	8.90	1.11
A 4297	Dissolved Bone Phosphate with Potash '16	Fowlerville		0.66	0.10	0.11	0.87	9.45	0.84	8.61	1.16
A 4166*	Dissolved Bone Phosphate with Potash '16	Port Hope		0.52	0.20	0.22	0.94	10.50	1.00	9.50	1.01
		Average		0.61	0.14	0.14	0.89	9.86	0.91	8.92	1.10
			G.†				*1.65*			*8.00*	*1.00*
A 4083	Sea Fowl Guano with Potash	Buchanan	F.†	1.00	0.43	0.23	1.66	10.75	1.52	9.23	1.13
			G.†							*14.00*	
A 4491	Soluble Dissolved Bone Phosphate	Detroit	F.†					15.15	0.40	14.75	
	Crocker Brands										
	10% Acid Phosphate		G.†							*10.00*	
			G.†				*1.65*			*8.00*	*1.00*
A 3977	Ammoniated Wheat & Corn Phosphate 1916	Coral	F.†	0.83	0.48	0.36	1.67	10.00	1.28	8.72	1.16
			G.†				*1.65*			*8.00*	*1.00*
A 3669	Bean Grower	Pompeii	F.†	1.02	0.41	0.33	1.76	10.55	1.56	8.99	1.07
A 3976	Bean Grower	Coral		0.91	0.41	0.36	1.68	10.15	1.32	8.83	0.99
		Average		0.97	0.41	0.34	1.72	10.35	1.41	8.91	1.03
			G.†				*0.82*			*10.00*	*1.00*
A 3785	Complete Fertilizer	Eaton Rapids	F.†	0.67	0.13	0.18	0.98	12.05	1.08	10.97	1.00
	Dissolved Bone Phosphate		G.†							*14.00*	
			G.†							*16.00*	
A 3784	High Grade Phosphate	Eaton Rapids	F.†					18.65	1.16	17.49	
A 4281	High Grade Phosphate	Mason						18.90	0.80	18.10	
		Average						18.77	0.98	17.79	

			G.†	....	....	....	*0.82*	....	....	*9.00*	*1.00*
A 3736	New Rival Ammoniated Superphosphate '16	Eaton Rapids	F.†	0.65	0.12	0.16	0.93	9.65	1.06	8.59	1.00
A 4461	New Rival Ammoniated Superphosphate '16	New Boston		0.41	0.15	0.16	0.75	10.10	1.08	9.02	1.10
		Average		0.55	0.13	0.16	0.84	9.88	1.07	8.81	1.05
			G.†	....	....	....	*0.82*	....	....	*9.00*	*1.00*
A 3968	Sugar Beet Fertilizer	Pompeii	F.†	0.70	0.09	0.11	0.90	9.80	0.86	8.94	1.00
	Michigan Carbon Works Brands										
			G.†	....	....	....	*0.82*	....	....	*8.00*	*3.00*
A 3753	A-1 Potash Fertilizer	Blissfield	F.†	0.63	0.06	0.15	0.84	10.30	0.86	9.44	3.07
A 4289	A-1 Potash Fertilizer	Lansing		0.61	0.12	0.16	0.89	9.95	0.78	9.17	3.53
		Average		0.62	0.09	0.15	0.86	10.13	0.82	9.31	3.30
			G.†	....	....	....	*0.82*	....	....	*8.00*	*1.00*
A 3705	A-1 Potash Fertilizer 1916	Pontiac	F.†	0.62	0.12	0.20	0.94	10.90	1.26	9.64	1.05
A 3736	A-1 Potash Fertilizer 1916	Richmond		0.70	0.08	0.20	0.98	10.45	1.36	0.09	1.11
A 3750	A-1 Potash Fertilizer 1916	Davis		0.66	0.09	0.16	0.91	9.80	1.06	8.74	1.12
A 3778	A-1 Potash Fertilizer 1916	Saline		0.65	0.10	0.15	0.90	8.90	1.01	7.86	1.20
A 4034	A-1 Potash Fertilizer 1916	Coopersville		0.60	0.14	0.13	0.87	10.65	1.06	9.59	1.01
A 4535*	A-1 Potash Fertilizer 1916	Utica		0.46	0.19	0.22	0.87	10.40	1.20	9.20	1.01
		Average		0.61	0.12	0.18	0.91	10.18	1.16	9.02	1.08
			G.†	....	....	....	....	....	....	*10.00*	*5.00*
A 3738	High Potash Phosphate	Richmond	F.†	....	....	....	....	12.90	1.10	11.80	4.94
A 3920	High Potash Phosphate	South Haven		....	....	....	....	12.55	1.08	11.47	4.95
A 4288	High Potash Phosphate	Lansing		....	....	....	....	11.85	0.90	10.95	4.11
A 4157*	High Potash Phosphate	Caro		....	....	....	....	11.25	0.36	10.89	5.08
A 4673*	High Potash Phosphate	Flushing		....	....	....	....	11.30	0.26	11.04	5.19
		Average		....	....	....	....	11.97	0.74	11.23	4.91
			G.†	....	....	....	*0.82*	....	....	*10.00*	....
A 3706	New Standard Fertilizer	Pontiac	F.†	0.58	0.18	0.19	0.95	13.45	2.02	11.43	....
A 3717	New Standard Fertilizer	Romeo		0.69	0.16	0.16	1.01	13.15	1.50	11.65	....
A 3737	New Standard Fertilizer	Richmond		0.45	0.16	0.22	0.83	12.80	1.80	11.00	....
A 3751	New Standard Fertilizer	Davis		0.62	0.22	0.17	1.01	12.65	1.74	10.91	....
A 3799	New Standard Fertilizer	Jonesville		0.70	0.18	0.14	1.02	12.15	1.48	10.67	....
A 4033	Nəw Standard Fertilizer	Coopersville		0.59	0.23	0.12	0.94	12.65	1.58	11.07	....
		Average		0.61	0.19	0.16	0.96	12.81	1.69	11.12	....
			G.†	....	....	....	*1.65*	....	....	*8.00*	*2.00*
A 3777	Red Line Crop Grower	Saline	F.†	1.42	0.20	0.15	1.77	9.60	1.46	8.14	1.98
A 4341	Red Line Crop Grower	Henderson		1.39	0.23	0.21	1.83	9.80	1.36	8.44	1.96
A 4126*	Red Line Crop Grower	Caledonia		1.08	0.33	0.36	1.77	10.15	1.30	8.85	2.65
		Average		1.29	0.26	0.24	1.79	9.85	1.37	8.48	2.20

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	American Agricultural Chemical Co.—Cont.										
	Michigan Carbon Works Brands—Cont.										
			G.†	....	....	....	....	....	....	*14.00*	....
A 4036	Red Line Phosphate	Coopersville	F.†	....	....	....	....	16.70	0.86	15.84	....
A 4425	Red Line Phosphate	Milan		....	....	....	....	17.00	1.16	15.84	....
		Average		....	....	....	....	16.85	1.01	15.84	....
			G.†	....	....	....	....	....	....	*10.00*	*2.00*
A 3739	Red Line Phosphate with Potash	Richmond	F.†	....	....	....	....	12.80	1.26	11.54	1.92
A 4004	Red Line Phosphate with Potash	Jamestown		....	....	....	....	13.25	1.26	11.99	1.81
A 4217	Red Line Phosphate with Potash	Quincy		....	....	....	....	12.05	0.62	11.43	2.35
A 4672*	Red Line Phosphate with Potash	Grand Rapids		....	....	....	....	11.05	0.54	10.51	1.29
		Average		....	....	....	....	12.29	0.92	11.37	1.84
			G.†	....	....	....	*1.65*	....	....	*10.00*	....
A 3954	Soil Builder	Fennville	F.†	1.39	0.31	0.14	1.84	12.85	2.28	10.57	....
A 4486	Soil Builder	Columbus		1.44	0.26	0.13	1.83	12.95	1.78	11.17	....
A 4507	Soil Builder	Okemos		1.67	0.25	0.10	2.12	13.05	1.70	11.35	....
		Average		1.50	0.27	0.16	1.93	12.95	1.92	11.03	....
			G.†	....	....	....	....	....	....	*16.00*	....
A 3718	Superior Acid Phosphate	Romeo	F.†	....	....	....	....	18.90	1.06	17.84	....
A 3749	Superior Acid Phosphate	Davis		....	....	....	....	17.60	0.38	17.22	....
A 4019	Superior Acid Phosphate	Grand Rapids		....	....	....	....	18.93	1.06	17.87	....
A 4005	Superior Acid Phosphate	Jamestown		....	....	....	....	19.05	1.02	18.03	....
A 4587*	Superior Acid Phosphate	Quincy		....	....	....	....	18.10	1.42	16.68	....
		Average		....	....	....	....	18.52	0.99	17.53	....
			G.†	....	....	....	*1.65*	....	....	*12.00*	....
A 3794	Triaton Fertilizer	Homer	F.†	1.24	0.30	0.23	1.77	14.60	1.30	13.30	....
A 4020	Triaton Fertilizer	Grand Rapids		1.20	0.38	0.18	1.76	15.20	1.30	13.90	....
A 4037	Triaton Fertilizer	Coopersville		1.29	0.38	0.18	1.85	15.45	1.24	14.21	....
A 4202	Triaton Fertilizer	Jonesville		1.08	0.34	0.24	1.66	14.30	1.12	13.18	....
		Average		1.20	0.35	0.21	1.76	14.89	1.24	13.65	....

			G.†	...	...	...	...	...	...	*12.00*	*2.00*
A 3978	Use More Fertilizer	Coopersville	F.†	...	...	...	...	14.35	0.98	13.37	1.98
			G.†	...	...	...	...	...	...	*10.00*	...
A 4658*	Wolverine Phosphate	Romulus	F.†	...	...	...	...	12.05	0.68	11.37	...
A 4170*	Wolverine Phosphate	Melvin		...	...	...	...	12.30	0.58	11.72	...
		Average		...	...	...	...	12.17	0.63	11.54	...
	Michigan Carbon Works Homestead Brands										
			G.†	...	...	...	*1.65*	...	...	*8.00*	*1.00*
A 3835	Bean Fertilizer 1916	Fennville	F.†	1.31	0.25	0.21	1.77	10.75	1.18	9.57	1.02
			G.†	...	...	...	*0.82*	...	...	*10.00*	*1.00*
A 3757	Bialode Fertilizer	Blissfield	F.†	0.63	0.11	0.21	0.95	12.55	1.18	11.37	1.06
A 3793	Bialode Fertilizer	Homer		0.68	0.14	0.15	0.97	12.35	1.06	11.29	1.01
A 4035	Bialode Fertilizer	Coopersville		0.70	0.14	0.18	1.02	13.30	1.66	11.64	1.06
		Average		0.67	0.13	0.18	0.98	12.73	1.30	11.43	1.04
			G.†	...	...	...	*1.65*	...	...	*8.00*	*1.00*
A 3758	Bone Black Fertilizer with Potash	Blissfield	F.†	1.24	0.21	0.21	1.66	10.45	1.28	9.17	1.01
A 3795	Bone Black Fertilizer with Potash	Homer		0.98	0.45	0.31	1.74	10.65	1.64	9.01	0.99
A 3858	Bone Black Fertilizer with Potash	Hastings		1.23	0.33	0.18	1.74	10.55	2.00	8.55	1.38
A 4287	Bone Black Fertilizer with Potash	Lansing		1.30	0.05	0.26	1.61	10.55	0.36	10.19	1.55
A 4536*	Bone Black Fertilizer with Potash	Utica		0.86	0.58	0.43	1.87	10.20	1.18	9.02	1.09
		Average		1.12	0.32	0.28	1.72	10.48	1.29	9.19	1.20
			G.†	...	...	...	*0.82*	...	...	*8.00*	*1.00*
A 4501	Bone Black Sugar Beet	Reese	F.†	0.59	0.14	0.20	0.93	10.65	1.34	9.31	1.41
			G.†	...	...	...	*1.65*	...	...	*12.00*	*3.00*
A 3837	Grain Fertilizer	Fennville	F.†	0.92	0.57	0.30	1.79	14.60	1.68	12.92	3.32
A 4437	Grain Fertilizer	Holly		1.22	0.28	0.20	1.70	14.00	0.72	13.28	3.01
		Average		1.07	0.42	0.25	1.74	14.30	1.20	13.10	3.16
			G.†	...	...	...	*1.65*	...	...	*8.00*	*5.00*
A 3756	High Grade Garden & Vegetable Fertilizer	Blissfield	F.†	1.27	0.21	0.25	1.73	10.20	0.52	9.68	4.84
A 4125*	High Grade Garden & Vegetable Fertilizer	Caledonia		0.98	0.34	0.36	1.68	10.55	1.30	9.25	5.43
A 4671*	High Grade Garden & Vegetable Fertilizer	Henderson		1.11	0.35	0.30	1.76	10.10	1.14	8.96	4.92
		Average		1.12	0.30	0.30	1.72	10.28	0.99	9.29	5.04
			G.†	...	...	...	*0.82*	...	...	*8.00*	*2.00*
A 3759	Special Potash Fertilizer	Blissfield	F.†	0.67	0.07	0.14	0.88	9.65	1.10	8.55	2.26
A 3776	Special Potash Fertilizer	Saline		0.67	0.14	0.13	0.94	10.30	1.16	9.14	2.00
A 3800	Special Potash Fertilizer	Jonesville		0.63	0.07	0.17	0.87	9.65	1.26	8.39	2.06
A 3836	Special Potash Fertilizer	Fennville		0.53	0.13	0.25	0.91	9.95	0.72	9.23	2.39
A 4561*	Special Potash Fertilizer	Hartland		0.50	0.06	0.31	0.87	10.30	0.78	9.52	2.16
		Average		0.60	0.09	0.20	0.89	9.97	1.00	8.97	2.17

†Abbreviations for Guaranteed and Found.
*Fall Samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	American Agricultural Chemical Co.—Cont.										
	Michigan Carbon Works Homestead Brands—Cont.										
			G.†				*0.82*			*9.00*	*1.00*
A 4383	Sugar Beet Fertilizer 1916	Ottawa Lake	F.†	0.64	0.17	0.14	0.95	10.45	1.23	9.17	1.15
	Michigan State Grange Brands										
			G.†				*0.82*			*8.00*	*1.00*
A 4397	All Crops Special Fertilizer 1916	Temperance	F.†	0.53	0.14	0.17	0.84	10.25	0.86	9.39	1.04
			G.†				*0.82*			*10.00*	*1.00*
A 4410	Ammoniated Bone and Potash	Monroe	F.†	0.70	0.15	0.19	1.04	12.80	1.50	11.30	1.17
A 4425	Ammoniated Bone and Potash	Monroe		0.65	0.18	0.19	1.02	12.75	1.12	11.63	1.14
		Average		0.68	0.16	0.19	1.03	12.78	1.31	11.47	1.15
			G.†				*1.65*			*10.00*	
A 4394	Corn and Oats Fertilizer	Temperance	F.†	1.28	0.24	0.26	1.78	12.15	1.72	10.43	
			G.†							*12.00*	*2.00*
A 4411	High Grade Phosphate and Potash	Monroe	F.†					13.30	0.62	12.68	2.13
			G.†				*0.82*			*10.00*	
A 4171*	IX Fertilizer	Brown City	F.†	0.42	0.17	0.22	0.81	12.45	1.04	11.41	
			G.†							*16.00*	
A 4395	Wheat Fertilizer Extra	Erie	F.†					19.30	1.22	18.08	
A 4398	Wheat Fertilizer Extra	Temperance						19.80	1.40	18.40	
		Average						19.55	1.31	18.24	
			G.†							*14.00*	
A 4396	Wheat Fertilizer No. 1	Temperance	F.†					16.60	0.58	16.02	
	Niagara Brands										
	Acid Phosphate 10%		*G.*†							*10.00*	
	Bean Grower		*G.*†				*1.65*			*8.00*	*1.00*

			G.†							*14.00*	
A 4481	Dissolved Bone Phosphate	Capac	F.†					16.35	0.38	15.97	
A 4488	Dissolved Bone Phosphate	Adair						16.55	0.26	16.29	
		Average						16.45	0.32	16.13	
			G.†				*0.82*			*10.00*	*1.00*
A 4649*	General Crop	Hillsdale	F.†	0.49	0.16	0.22	0.87	12.05	1.22	10.83	1.13
A 4659*	General Crop	Monroe		0.49	0.16	0.23	0.88	12.75	1.16	11.59	1.13
		Average		0.49	0.16	0.22	0.87	12.40	1.19	11.21	1.13
			G.†							*16.00*	
A 3715	High Grade Phosphate	Washington	F.†					18.85	0.90	17.95	
A 3734	High Grade Phosphate	Richmond						18.65	1.06	17.59	
		Average						18.75	0.98	17.77	
			G.†				*0.82*			*9.00*	*1.00*
A 4405	Wheat and Corn Producer 1916	Erie	F.†	0.70	0.11	0.10	0.91	9.95	1.02	8.93	1.20
	Northwestern Horse Shoe Brands										
			G.†				*0.82*			*10.00*	*1.00*
A 4418	Acidulated Bone Phosphate and Potash	Petersburg	F.†	0.62	0.14	0.18	0.94	12.30	1.22	11.08	1.13
			G.†				*1.65*			*8.00*	*1.00*
A 4363*	Bean Special 1916	Swartz Creek	F.†	0.85	0.42	0.34	1.61	10.68	1.58	9.10	1.16
			G.†							*10.00*	*2.00*
A 3741	Bone Phosphate and Potash	Lenox	F.†					12.20	0.82	11.38	2.05
			G.†				*1.65*			*8.00*	*2.00*
A 3771	Corn and Wheat Grower	Adrian	F.†	1.45	0.16	0.15	1.76	10.10	1.24	8.86	1.92
A 3779	Corn and Wheat Grower	Saline		1.52	0.16	0.13	1.81	9.70	1.38	8.32	1.85
A 3914	Corn and Wheat Grower	Hartford		1.44	0.28	0.04	1.76	9.90	1.20	8.70	1.74
A 4362	Corn and Wheat Grower	Swartz Creek		1.39	0.19	0.25	1.83	10.05	1.22	8.83	1.89
A 4627*	Corn and Wheat Grower	Saline		1.10	0.32	0.31	1.73	10.15	1.08	9.07	2.30
A 4645*	Corn and Wheat Grower	Adrian		1.44	0.18	0.19	1.81	9.85	1.30	8.55	2.02
		Average		1.39	0.21	0.18	1.78	9.96	1.24	8.72	1.95
			G.†				*1.65*			*12.00*	
A 4222	Dissolved Ammoniated Bone Phosphate	Coldwater	F.†	1.34	0.34	0.18	1.86	15.20	1.34	13.86	
A 4299	Dissolved Ammoniated Bone & Phosphate	Howell		1.20	0.33	0.20	1.73	14.55	1.14	13.41	
		Average		1.27	0.33	0.19	1.79	14.87	1.24	13.63	

†Abbreviations for Guaranteed and Found.
*Fall Samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at	Nitrogen.				Phosphoric acid.			Potash.
			As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	American Agricultural Chemical Co.—Cont.									
	Northwestern Horseshoe Brands—Cont.									
		G.†				*0.82*			*10.00*	
A 3740	F. & F. Fertilizer	Lenox F.†	0.55	0.22	0.17	0.94	12.75	1.40	11.35	
A 4312	F. & F. Fertilizer	Reading	0.60	0.22	0.12	0.94	12.75	1.76	10.99	
A 4547*	F. & F. Fertilizer	Richmond	0.46	0.18	0.19	0.83	12.05	1.32	10.73	
		Average	0.54	0.21	0.16	0.91	12.51	1.49	11.02	
		G.†				*1.65*			*8.00*	*1.00*
A 3913	Garden City Superphosphate with Potash	Coloma F.†	1.45	0.28	0.11	1.84	10.75	1.24	9.51	0.96
	High Grade Vegetable Fertilizer	G.†				*1.65*			*8.00*	*5.00*
		G.†							*16.00*	
A 3769	16% Phosphate	Adrian F.†					18.40	0.96	17.44	
A 4223	16% Phosphate	Coldwater					18.20	0.22	17.98	
A 4301	16% Phosphate	Howell					19.10	1.10	18.00	
		Average					18.57	0.76	17.81	
		G.†				*0.82*			*8.00*	*2.00*
A 4296	2 Potash Fertilizer	Williamston F.†	0.68	0.10	0.14	0.92	9.85	0.58	9.27	2.03
A 4137*	2 Potash Fertilizer	Battle Creek	0.53	0.10	0.25	0.88	10.20	1.01	9.19	2.11
A 4546*	2 Potash Fertilizer	Richmond	0.55	0.10	0.18	0.83	10.35	0.98	9.37	2.02
		Average	0.59	0.10	0.19	0.88	10.14	0.86	9.28	2.05
		G.†							*10.00*	*5.00*
A 4508	10-5 Potash Manure	Clinton F.†					11.60	0.28	11.32	6.45
A 4136*	10-5 Potash Manure	Battle Creek					11.40	0.40	11.00	5.04
		Average					11.50	0.34	11.16	5.74
		G.†				*0.82*			*8.00*	*3.00*
A 3742	Potash Manure	Lenox F.†	0.64	0.12	0.16	0.92	10.70	0.80	9.90	3.07
A 4300	Potash Manure	Howell	0.55	0.10	0.21	0.86	9.60	0.60	9.00	3.00
		Average	0.59	0.11	0.19	0.89	15.01	0.70	9.45	3.03

			G.†				0.82			8.00	1.00
A 3728	Potash Manure 1916	Plymouth	F.†	0.70	0.11	0.16	0.97	10.20	1.20	9.00	1.14
A 3743	Potash Manure 1916	Lenox		0.72	0.10	0.19	1.01	10.65	1.48	9.17	1.20
A 3770	Potash Manure 1916	Adrian		0.72	0.09	0.16	0.97	9.95	1.36	8.59	1.09
A 4548*	Potash Manure 1916	Richmond		0.53	0.16	0.19	0.88	10.00	0.86	9.14	1.13
		Average		0.67	0.12	0.17	0.96	10.20	1.22	8.98	1.14
			G.†							10.00	
A 3772	Quick Acting Phosphate	Adrian	F.†					11.10	0.36	10.74	
A 4664*	Quick Acting Phosphate	Adrian						11.60	0.38	11.22	
		Average						11.35	0.37	10.98	
			G.†				1.65			10.00	
A 4295	Special Dissolved Amophos	Williamston	F.†	1.42	0.21	0.17	1.80	12.45	1.36	11.09	
			G.†				1.65			12.00	3.00
A 4361	Special Grain Fertilizer	Swartz Creek	F.†	1.37	0.22	0.15	1.74	13.35	0.64	12.71	3.39
A 4626*	Special Grain Fertilizer	Saline		1.13	0.33	0.25	1.71	14.05	1.68	12.37	3.68
		Average		1.25	0.27	0.20	1.72	13.70	1.16	12.54	3.53
			G.†							14.00	
A 4359	Square Deal Phosphate	Swartz Creek	F.†					15.80	0.26	15.54	
			G.†				0.82			9.00	1.00
A 4343	Sugar Beet Fertilizer 1916	Oakley	F.†	0.67	0.12	0.16	0.95	9.78	0.86	8.92	1.30
			G.†							12.00	2.00
A 4417	XXX Fertilizer	Petersburg	F.†					13.75	0.68	13.07	2.10
	Packers Boar's Head Brands										
			G.†				0.82			10.00	1.00
A 3970	Ammoniated Bone Phosphate and Potash	North Star	F.†	0.63	0.17	0.15	0.95	11.90	1.32	10.58	1.13
A 4509	Ammoniated Bone Phosphate and Potash	Wyandotte		0.40	0.17	0.22	0.79	12.10	1.16	10.94	1.20
		Average		0.51	0.17	0.19	0.87	12.00	1.24	10.76	1.16
			G.†				1.65			12.00	3.00
A 3953	Best Grain Fertilizer	Holland	F.†	1.04	0.46	0.27	1.77	14.50	1.28	13.22	3.24
A 4468	Best Grain Fertilizer	Holland		1.39	0.19	0.15	1.73	14.25	0.78	13.47	3.01
A 4657*	Best Grain Fertilizer	Romulus		1.17	0.31	0.22	1.70	14.00	1.54	12.46	3.45
		Average		1.20	0.32	0.21	1.73	14.25	1.20	13.05	3.23
			G.†				1.65			8.00	2.00
A 4472	Corn and Wheat Grower	Clarkston	F.†	1.08	0.43	0.30	1.81	10.95	1.24	9.71	2.33
			G.†							10.00	2.00
A 3745	Dissolved Phosphate and Potash	Lenox	F.†					12.85	1.58	11.27	2.02

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	American Agricultural Chemical Co.—Cont.										
	Packers Boar's Head Brands—Cont.										
	Gilt Edge Phosphate		*G.*†	....	....	....	....	....	....	*14.00*	....
			G.†	....	....	....	*1.65*	....	....	*8.00*	*5.00*
A 4173	High Grade Vegetable Fertilizer	Clarkston	F.†	0.94	0.43	0.36	1.73	11.05	1.20	9.85	5.25
			G.†	....	....	....	*0.82*	....	....	*10.00*	....
A 3744	New Compound	Lenox	F.†	0.52	0.23	0.19	0.94	12.65	1.62	11.03	....
A 3880	New Compound	Harlem		0.56	0.21	0.13	0.90	12.80	1.86	10.94	....
A 4107*	New Compound	Zeeland		0.55	0.30	0.22	1.07	13.20	1.34	11.86	....
		Average		0.54	0.25	0.18	0.97	12.88	1.61	11.27	....
			G.†	....	....	....	*0.82*	....	....	*8.00*	*2.00*
A 4337	New Compound and Potash Fertilizer	Bancroft	F.†	0.71	0.11	0.16	0.98	10.00	1.08	8.92	2.10
			G.†	....	....	....	....	....	....	*16.00*	....
A 4368	16% Phosphate	Lennon	F.†	....	....	....	....	17.90	0.52	17.38	....
A 3882	16% Phosphate	Harlem		....	....	....	....	18.80	1.12	17.68	....
		Average		....	....	....	....	18.35	0.82	17.53	....
			G.†	....	....	....	....	....	....	*12.00*	*2.00*
A 4177*	Phospotash Fertilizer	Kent City	F.†	....	....	....	....	13.60	0.44	13.16	2.10
	Potash Phosphate Fertilizer		*G.*†	....	....	....	*1.65*	....	....	*12.00*	....
	Soluble Phosphate		*G.*†	....	....	....	....	....	....	*10.00*	....
			G.†	....	....	....	*1.65*	....	....	*12.00*	....
A 3952	Success Fertilizer	Holland	F.†	1.36	0.36	0.13	1.85	15.10	1.28	13.82	....
A 4106*	Success Fertilizer	Zeeland		0.78	0.58	0.40	1.76	15.20	1.26	13.94	....
		Average		1.07	0.47	0.27	1.81	15.15	1.27	13.88	....
			G.†	....	....	....	*0.82*	....	....	*9.00*	*1.00*
A 4632*	Sugar Beet Grower 1916	Willis	F.†	0.65	0.09	0.13	0.87	10.00	0.82	9.18	1.20

			G.†				*0.82*			*8.00*	*3.00*
A 4338	Sure Growth Potash Manure	Bancroft	F.†	0.53	0.12	0.23	0.88	9.30	0.92	8.38	3.40
A 4347	Sure Growth Potash Manure	Montrose		0.54	0.11	0.23	0.88	9.85	0.64	9.21	2.94
		Average		0.53	0.12	0.23	0.88	9.57	0.78	8.79	3.17
			G.†				*0.82*			*8.00*	*1.00*
A 3746	Sure Growth Potash Manure 1916	Lenox	F.†	0.66	0.10	0.18	0.94	10.65	1.46	9.19	1.23
A 3881	Sure Growth Potash Manure 1916	Harlem		0.56	0.15	0.22	0.93	10.40	1.18	9.22	1.03
		Average		0.61	0.13	0.20	0.94	10.53	1.32	9.21	1.13
			G.†				*1.65*			*10.00*	
A 4494	2 and 10 Compound	Romulus	F.†	1.35	0.31	0.21	1.87	12.40	1.68	10.72	
	World of Good Superphosphate with Potash		G.†				*1.65*			*8.00*	*1.00*
	Armour Fertilizer Works Chicago Ill.										
			G.†				*1.65*			*10.00*	
A 3843	Ammoniated Phosphate No. 2	Byron Center	F.†	1.04	0.42	0.11	1.60	13.20	2.34	10.86	
			G.†							*10.00*	
A 4360	Cereal Phosphate	Schwartz Creek	F.†					11.60	1.10	10.50	
			G.†				*1.65*			*8.00*	*2.00*
A 3847	Grain Grower	Plainwell	F.†	0.51	0.54	0.43	1.48	11.05	1.84	9.21	2.79
A 4012	Grain Grower	Grand Rapids		0.89	0.44	0.30	1.63	12.35	2.28	10.07	2.47
A 4072	Grain Grower	Decatur		0.76	0.47	0.36	1.59	11.45	2.12	9.33	2.42
A 4206	Grain Grower	Quincy		0.66	0.42	0.25	1.33	9.83	1.86	7.97	1.66
		Average		0.71	0.47	0.33	1.51	11.17	2.02	9.15	2.34
			G.†								*14.00*
A 4078	Kainit	Decatur	F.†								14.32
			G.†				*0.82*			*8.00*	*1.00*
A 3747	Michigan Special	Romeo	F.†	0.31	0.22	0.24	0.80	10.55	1.22	9.33	1.10
A 3763	Michigan Special	Blissfield		0.33	0.24	0.24	0.81	9.80	1.24	8.56	0.68
A 4002	Michigan Special	Caledonia		0.35	0.25	0.15	0.75	11.15	1.36	9.79	1.19
A 4016	Michigan Special	Grand Rapids		0.39	0.31	0.21	0.91	11.35	1.62	9.73	2.21
A 4529*	Michigan Special	Utica		0.43	0.28	0.13	0.81	8.93	1.14	7.79	1.01
		Average		0.37	0.26	0.19	0.82	10.36	1.32	9.04	1.24
			G.†							*10.00*	*1.00*
A 4028	Phosphate and Potash Special	Coopersville	F.†					11.70	0.64	11.06	0.68
			G.†				*1.24*			*1.00*	*1.00*
A 3901	Sheep Manure	Portage	F.†	0.16	0.45	1.01	1.62	1.15	0.34	0.81	3.18

†Abbreviations for Guaranteed and Found.
*Fall Samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Armour Fertilizer Works—Cont.										
			G.†	....	....	....	*1 65*	....	....	*8.00*	*1.00*
A 4209	Special Grain Grower	Quincy	F.†	0 90	0 47	0 27	1 64	10 00	1 96	8 04	0.99
A 4349	Special Grain Grower	Flushing		0 78	0 51	0 37	1 66	10.55	2.58	7.97	1.45
		Average		0 84	0 49	0 32	1.65	10.27	2.27	8.00	1.22
			G.†	....	....	....	*0 82*	....	....	*8.00*	*3.00*
A 4017	Standard	Grand Rapids	F.†	0 46	0 24	0 14	0 84	13 33	5 68	**7 65**	**2.52**
A 4030	Standard	Coopersville		0 38	0 21	0 18	0 77	13.05	5 00	8.05	**2.62**
A 4073	Standard	Decatur		0 44	0 30	0 20	0 94	10 80	1 48	9.32	**1.65**
A 4229	Standard	Ann Arbor		0 67	0 26	0 15	1 08	12.70	4.62	8.08	**2.44**
		Average		0 49	0 24	0 17	0.90	12 47	4.19	8.28	**2.31**
			G.†	....	....	....	....	....	....	*14 00*	....
A 3846	Star Phosphate	Byron Center	F.†	....	....	....	....	13.00	0.64	**12 36**	....
A 4421	Star Phosphate	Deerfield		....	....	....	....	16.15	0.14	16.01	....
		Average		....	....	....	....	14 75	0.39	14.18	....
			G.†	....	....	....	*0 82*	....	....	*7.00*	*1.00*
A 3848	Wheat, Corn and Oats Special	Plainville	F.†	0 31	0 24	0.20	0 75	8.45	1.04	7.41	1.15
A 4029	Wheat, Corn and Oats Special	Coopersville		0 41	0 24	0.15	0 80	9 90	1.48	8.42	1.02
A 4210	Wheat, Corn and Oats Special	Quincy		0 35	0 29	0 17	0 81	8 80	1 40	7.40	0.99
A 4350	Wheat, Corn and Oats Special	Flushing		0.46	0.34	0.18	0 98	9 50	1.68	7.82	0 99
A 4560*	Wheat, Corn and Oats Special	Disco		0 55	0.19	0 06	0 80	8.35	0.60	7.75	0.91
		Average		0.41	0 26	0 15	0.82	9.00	1.24	7.76	1.01
			G.†	....	....	....	*0 82*	....	....	*10.00*	....
A 3845	1-10 Fertilizer	Byron Center	F.†	0.36	0 31	0 17	0 84	11.55	1.40	10.15	....
A 3932	1-10 Fertilizer	Casnovia		0.55	0 30	0 15	1 00	11.50	2.20	**9.30**	....
A 4530*	1-10 Fertilizer	Utica		0 44	0 28	0 11	0.83	11.05	1.06	9.99	....
		Average		0.45	0 30	0.14	0.89	11.36	1.55	9.81	....
			G.†	....	....	....	*0.82*	....	....	*12.00*	*1.00*
A 4050	1-12-1 Fertilizer	Zeeland	F.†	0.43	0 23	0.14	0 80	13.50	1.10	12.40	**0 73**
A 4204	1-12-1 Fertilizer	Jonesville		0.45	0.30	0.18	0.93	14.15	1.10	13.05	0 97
		Average		0.44	0.26	0.16	0 86	13.83	1.10	12.73	**0.85**

	Big Crop Brands		*G.*†	....	....	....	....	....	....	*16.00*	....
A 3748	16% Acid Phosphate	Romeo	F.†	....	....	....	....	18.15	0.68	17.47	....
A 4027	16% Acid Phosphate	Coopersville		....	....	....	....	18.80	0.42	18.38	....
A 4038	16% Acid Phosphate	Nuniea		....	....	....	....	18.70	1 00	17.70	....
A 4065	16% Acid Phosphate	Mattawan		....	....	....	....	18 85	0.80	18 05	....
A 4205	16% Acid Phosphate	Jonesville		....	....	....	....	17.80	0 14	17.66	....
		Average		....	....	....	....	18.46	0.61	17.85	....
			G.†	....	....	....	*1 65*	*27.00*	....	....	....
A 4001	Bone Meal	Caledonia	F.†	0 95	0 84	0 54	2.33	27.40	....	....	....
A 4015	Bone Meal	Grand Rapids		0 91	0 92	0 44	2 27	28.40	....	....	....
A 4230	Bone Meal	Ann Arbor		1.01	1 14	0 60	2 75	27.20	....	....	....
		Average		0 96	0 97	0.52	2.45	27.80	....	....	....
	Half Bone Meal Half Acid Phosphate	....	*G.*†	....	....	....	*1.23*	*20.00*	....	....	....
			G.†	....	....	....	*1.65*	....	....	*12.00*	....
A 3860	2-12 Fertilizer	Vermontville	F.†	0 54	0 67	0 35	1.56	16.08	2.66	13 42	....
A 4207	2-12 Fertilizer	Quincy		0 79	0 57	0.24	1.60	14.45	2 22	12.23	....
		Average		0 66	0 62	0 30	1.58	15.26	2 44	12.82	....
			G.†	....	....	....	....	....	....	*12 00*	*2 00*
A 3764	12-2 Brand	Blissfield	F.†	....	....	....	....	13 45	0 40	13.05	1 13
A 3859	12-2 Brand	Vermontville		....	....	....	....	13 50	1 00	12.50	0.97
		Average		....	....	....	....	13 47	0.70	12.77	1.05
			G.†	....	....	....	....	....	....	*12 00*	*4.00*
A 3849	12-4 Brand	Plainville	F.†	....	....	....	....	13 25	0.74	12.51	3 07
A 4031	12-4	Coopersville		....	....	....	....	13 55	0 74	12.81	3 21
A 4208	12-4 Brand	Quincy		....	....	....	....	14 25	2 87	11.38	2 90
A 4277	12-4 Brand	Hudson		....	....	....	....	13 25	0 82	12 43	3 14
		Average		....	....	....	....	13 57	1 29	12.28	3 08
			G.†	....	....	....	*1 65*	....	....	*10 00*	*4 00*
A 3844	2-10-4 Brand	Byron Center	F.†	0 93	0 55	0 47	1 95	12 10	2 38	9 72	3 69
A 4013	2-10-4 Brand	Grand Rapids		0 81	0.48	0 35	1 64	14 20	2.48	11 72	3 96
A 4071	2-10-4 Brand	Decatur		0 79	0 45	0 36	1 60	13 15	2 08	11 07	4.19
A 4276	2-10-4 Brand	Hudson		0 93	0 59	0 38	1 90	12.50	2 28	10 22	4 14
		Average		0 86	0 52	0 39	1 77	12.99	2 31	10 68	3 99

†Abbreviations for Guaranteed and Found.
*Fall Samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Armour Fertilizer Works—Cont.										
	Big Crop Brands—Cont.										
			G.†				*1.65*			*12.00*	*2.00*
A 4014	2-12-2 Brand	Grand Rapids	F.†	1.01	0.46	0.31	1.78	16.05	2.46	13.59	2.04
A 4275	2-12-2 Brand	Hudson		0.92	0.51	0.30	1.76	15.30	2.32	12.98	2.00
A 4203	2-12-2 Brand	Jonesville		0.71	0.57	0.36	1.64	15.20	2.24	12.96	2.11
		Average		0.88	0.52	0.32	1.72	15.51	2.34	13.17	2.05
	Tuscarora Brands										
			G.†							*14.00*	
A 3961	Acid Phosphate	New Buffalo	F.†					16.60	0.54	16.06	
	10% Phosphate		*G.*†							*10.00*	
	1-10 Fertilizer		*G.*†				*0.82*			*10.00*	
	Potash and Phosphate		*G.*†							*10.00*	*1.00*
			G.†				*0.82*			*8.00*	*1.00*
A 3960	Special Corn, Wheat and Bean Grower	New Buffalo	F.†	0.47	0.32	0.19	0.98	9.90	1.70	8.20	1.18
	Special Standard		*G.*†				*1.65*			*8.00*	*1.00*
	Standard		*G.*†				*1.65*			*8.00*	*2.00*
	Tankage and Phosphate		*G.*†				*1.65*			*10.00*	
	The Barrett Company, New York, N. Y.										
			G.†				*20.75*				
A 3727	Arcadian Sulphate of Ammonia	Plymouth	F.†				20.93				
A 4101	Arcadian Sulphate of Ammonia	Benton Harbor					21.08				
A 4251	Arcadian Sulphate of Ammonia	Tecumseh					21.02				
		Average					21.02				
	R. Binder Co., Battle Creek, Mich.										
			G.†				*5.25*	*13.17*			
A 3922	Blood and Bone	Battle Creek	F.†	3.02	1.67	1.05	5.74	16.70	9.68	7.02	

	N. Burleson, Swartz Creek, Mich.										
			G.†	....	....	....	*1 64*	....	....	*10.50*	
A 4358	Corn, Wheat and Beet Special	Swartz Creek	F.†	1 05	0 52	0 15	1 72	15 70	4 65	11.05	
A 4695*	Corn, Wheat and Beet Special	Swartz Creek		1.18	0 29	1 00	1.57	14 75	2 54	12.21	.....
		Average		1.11	0 41	0.12	1.64	15 22	3.59	11.63	.....
	E. Burton Fertilizer Co., St. Joseph, Mich.										
			G.†	....	....	....	*5 00*	....	....	*6 00*	....
A 3979	Meat and Bone Phosphate	St. Joseph	F.†	0.58	2 63	1 30	**4 51**	15.60	8 90	6.70	....
	Calumet Fertilizer Co., New Albany, Indiana										
			G.†	....	....	....	....	....	....	*14.00*	....
A 4416	14% Acid Phosphate	Petersburg	F.†	....	....	....	....	16 00	1 68	14.32	....
A 4476	14% Acid Phosphate	Leonard		....	....	....	....	15 90	1 26	14.64	....
A 4644*	14% Acid Phosphate	Petersburg		....	....	....	....	15 60	1.42	14.18	....
A 4074*	14% Acid Phosphate	Flushing		....	....	....	....	15.30	0 64	14 66	....
		Average		....	....	....	....	15 70	1.25	14 45	....
			G.†	....	....	....	....	....	....	*16 00*	....
A 4051	16% Acid Phosphate	Zeeland	F.†	....	....	....	....	17.35	0.56	16.79	....
A 4095	16% Acid Phosphate	Sawyer		....	....	....	....	18 25	2 30	15.95	....
A 4286	16% Acid Phosphate	Mason		....	....	....	....	17 40	0 36	17 04	....
A 4551*	16% Acid Phosphate	Richmond		....	....	....	....	16 85	1 30	**15 55**	....
		Average		....	....	....	....	17.46	1.13	16.33	....
			G.†	....	....	....	*1 20*	*16 00*	....	....	*1.00*
A 4666*	Bone Meal Tankage and Potash	Adrian	F.†	0.32	0 66	0.66	1.64	16.05	....	....	1.05
			G.†	....	....	....	*0.41*	....	....	*10 00*	*1.00*
A 3866	Bone Phosphate and Potash Mixture	Grand Ledge	F.†	0 14	0.11	0 17	0 42	10 90	0 58	10 32	**0.89**
A 4055	Bone Phosphate and Potash Mixture	Zeeland		0 10	0 11	0 27	0 48	11 15	0 82	10 33	1 09
A 4093	Bone Phosphate and Potash Mixture	Sawyer		0.23	0 11	0 11	0 45	11 05	1 08	9 97	1 00
A 4388	Bone Phosphate and Potash Mixture	Lulu		0.18	0 13	0 15	0.46	11 05	0 92	10 13	1 05
A 4111*	Bone Phosphate and Potash Mixture	Zeeland		0 15	0 13	0 17	0 45	11.35	0 72	10 63	1 16
A 4645*	Bone Phosphate and Potash Mixture	Petersburg		0 24	0.16	0.16	0.56	10.80	0 72	10 08	1 03
		Average		0.17	0 13	0.17	0 47	11.05	0 81	10 24	1 04
			G.†	....	....	....	*0 60*	....	....	*8 00*	*0 50*
A 4389	Coburn's Special with Potash	Lulu	F.†	0 29	0.18	0.19	0 66	10 40	1 14	9.26	0.54
			G.†	....	....	....	*1 65*	....	....	*10 00*	*2.00*
A 4652*	Corn and Wheat Special	Mason	F.†	1.39	0 25	0 12	1 76	11.90	1.14	10.76	2 02
			G.†	....	....	....	*1.62*	....	....	*12 00*	....
A 4094	Extra Ammoniated Bone Phosphate	Sawyer	F.†	1 32	0 21	0 11	1 64	13 40	1 02	12.38	...

†Abbreviations for Guaranteed and Found.
*Fall Samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Calumet Fertilizer Co.—Cont.										
			G.†				*0.41*			*8.00*	*3.00*
A 3871	Half Eight Three	Sunfield	F.†	0.15	0.10	0.14	0.39	8.65	0.93	7.72	3.13
A 4364	Half Eight Three	Lennon		0.16	0.10	0.15	0.41	9.20	0.52	8.68	3.07
A 4110*	Half Eight Three	Zeeland		0.18	0.06	0.18	0.42	9.20	0.98	8.22	3.03
A 4550*	Half Eight Three	Richmond		0.22	0.08	0.16	0.46	9.05	1.00	8.05	3.06
		Average		0.18	0.08	0.16	0.42	9.02	0.86	8.16	3.07
	Half Seven Ten		*G.*†				*0.41*			*7.00*	*10.00*
			G.†				*0.41*			*10.00*	*2.00*
A 4483	Half Ten Two	Memphis	F.†	0.24	0.08	0.14	0.46	11.95	1.30	10.65	2.21
A 4688*	Half Ten Two	Charlotte		0.20	0.09	0.13	0.42	11.05	0.86	10.19	2.11
A 4689*	Half Ten Two	Olivet		0.24	0.16	0.22	0.62	10.90	0.82	10.08	2.04
		Average		0.23	0.11	0.16	0.50	11.30	0.99	10.31	2.12
			G.†				*0.41*			*13.00*	*1.00*
A 4096	One Half Thirteen One	Sawyer	F.†	0.25	0.10	0.17	0.52	17.35	4.12	13.23	1.00
A 4284	One Half Thirteen One	Mason		0.21	0.09	0.15	0.45	15.58	3.09	**12.49**	1.07
		Average		0.23	0.09	0.16	0.48	16.46	3.60	12.86	1.03
	High Grade Manure		*G.*†				*1.23*			*9.00*	*1.00*
			G.†				*2.47*			*10.00*	*4.00*
A 4654*	High Grade Tobacco and Truck Grower	Mason	F.†	2.15	0.43	0.02	2.60	12.30	2.26	10.04	**3.79**
			G.†				*0.82*			*8.00*	*3.00*
A 4282	Onion and Beet Grower	Mason	F.†	0.45	0.18	0.35	0.98	9.80	1.62	8.18	3.24
A 4459	Onion and Beet Grower	Waltz		0.42	0.19	0.23	0.84	9.15	1.79	**7.36**	**2.86**
		Average		0.43	0.19	0.29	0.91	9.47	1.70	**7.77**	3.05

			G.†				*1.62*			*8.00*	*8.00*
A 4283	Onion and Potato Grower	Mason	F.†	1.04	0.16	0.12	**1.32**	10.75	1.78	8.97	**7.74**
A 4387	Onion and Potato Grower	Lulu		1.04	0.19	0.27	**1.50**	9.70	2.03	**7.67**	**7.00**
A 4655*	Onion and Potato Grower	Mason		1.40	0.16	0.22	1.78	10.15	1.92	8.23	8.15
		Average		1.16	0.17	0.20	1.53	10.20	1.91	8.29	**7.63**
			G.†							*10.00*	*2.00*
A 3945	Phosphate and Potash	Zeeland	F.†					11.65	1.38	10.27	**1.78**
A 4354	Phosphate and Potash	Grand Blanc						11.40	0.62	10.78	2.01
A 4365	Phosphate and Potash	Lennon						10.98	1.55	**9.43**	1.97
A 4415	Phosphate and Potash	Petersburg						11.28	1.96	**9.32**	2.21
A 4477	Phosphate and Potash	Leonard						11.95	1.20	10.75	**1.56**
A 4569*	Phosphate and Potash	Grand Blanc						10.70	0.68	10.02	**1.80**
		Average						11.32	1.23	10.09	**1.89**
			G.†				*0.41*			*12.00*	
A 4092	Special Crop Grower	Sawyer	F.†	0.11	0.12	0.20	0.43	13.50	1.50	12.00	
A 4484	Special Crop Grower	Memphis		0.17	0.12	0.12	0.41	12.80	0.54	12.26	
		Average		0.14	0.12	0.16	0.42	13.15	1.02	12.13	
			G.†				*0.82*	*30.00*			
A 4285	Special Pure Bone Meal	Mason	F.†	0.17	0.41	0.22	0.80	**27.00**			
			G.†							*10.00*	*4.00*
A 3943	Ten Four	Zeeland	F.†					11.50	1.24	10.26	**3.64**
A 4366	Ten Four	Lennon						10.10	0.26	9.84	**3.82**
A 4675*	Ten Four	Flushing						11.75	1.30	10.45	**3.54**
		Average						11.11	0.93	10.18	**3.67**
			G.†							*10.00*	*10.00*
A 4479	Ten Ten Hummer	Almont	F.†					12.45	3.19	**9.26**	10.41
A 4142*	Ten Ten Hummer	Millington						12.88	3.45	**9.43**	10.06
A 4656*	Ten Ten Hummer	Mason						12.35	2.18	10.17	10.20
		Average						12.56	2.94	**9.62**	10.22
			G.†				*1.62*			*8.00*	*2.00*
A 4182*	Two Eight Two	Three Oaks	F.†	1.01	0.21	0.38	1.60	9.25	1.06	8.19	2.00
A 4653*	Two Eight Two	Mason		0.16	0.24	0.36	1.66	9.45	1.14	8.31	2.00
		Average		1.03	0.23	0.37	1.63	9.35	1.10	8.25	2.00
	Two Twelve Two		G.†				*1.64*			*12.00*	*2.00*

†Abbreviations for Guaranteed and Found.
*Fall Samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Chicago Feed & Fertilizer Co., Chicago, Illinois										
	Magic Brand Pulverized Sheep Manure		*G.*†				*1.85*			*1.43*	*1.25*
	Columbia Guano Co., Toledo, Ohio										
			G.†							*16.00*	
A 3708	16% Acid Phosphate	Birmingham	F.†					18.75	1.20	17.55	
A 3936	16% Acid Phosphate	Reeman						18.20	1.00	17.20	
A 4379	16% Acid Phosphate	Clayton						17.30	0.46	16.84	
		Average						18.08	0.89	17.19	
			G.†				*1.60*			*12.00*	
A 3933	Beacon Brand	Fremont	F.†	1.29	0.30	0.15	1.74	14.55	2.00	12.55	
A 3938	Beacon Brand	Reeman		1.31	0.32	0.14	1.77	14.85	2.40	12.45	
		Average		1.30	0.31	0.15	1.76	14.70	2.20	12.50	
			G.†				*0.80*			*8.00*	*5.00*
A 4393	Black Soil Guano	Petersburg	F.†	0.37	0.12	0.19	0.68	10.40	2.44	7.96	4.68
			G.†				*1.60*			*12.00*	*2.00*
A 4475	Bountiful Guano	Pontiac	F.†	1.33	0.21	0.10	1.64	14.90	1.18	13.72	2.06
A 4498	Extra Dry Guano	Mt. Morris	F.†	0.48	0.15	0.17	0.80	10.20	1.92	8.28	2.99
			G.†				*1.60*			*8.00*	*3.00*
A 3942	Fish and Potash	New Era	F.†	1.22	0.20	0.22	1.64	10.40	2.32	8.08	3.20
			G.†				*1.60*			*8.00*	*8.00*
A 3937	Fortune Guano	Reeman	F.†	1.04	0.28	0.32	1.64	10.05	1.36	8.69	8.50
			G.†				*0.80*			*8.00*	*1.00*
A 3941	Goodwill Guano	New Era	F.†	0.42	0.14	0.16	0.72	9.85	1.50	8.35	1.34
A 4392	Goodwill Guano	Petersburg		0.38	0.21	0.18	0.77	10.00	1.72	8.28	1.00
		Average		0.40	0.17	0.17	0.74	9.92	1.61	8.31	1.17
			G.†				*1.20*			*13.00*	
A 3946	Half & Half Bone and Phosphate	Paw Paw	F.†	0.57	0.45	0.22	1.24	21.02	9.75	11.27	

			G.†				*1.60*			*10.00*	*4.00*
A 4470	Immense Guano	Birch Run	F.†	1.39	0.22	0.19	1.80	12.65	1.26	11.39	4.99
			G.†							*10.00*	*8.00*
A 3947	10–8 Phosphate and Potash	Paw Paw	F.†					12.05	1.06	10.99	7.35
			G.†							*12.00*	*2.00*
A 4391	12–2 Phospate and Potash	Petersburg	F.†					13.90	1.83	12.07	1.75
			G.†							*12.00*	*4.00*
A 4469	12–4 Phosphate and Potash	Clio	F.†					15.15	2.66	12.49	4.40
	Prize Guano		G.†				*1.60*			*8.00*	*5.00*
	Special Fish Guano		G.†				*0.80*			*11.00*	*2.00*
	Success Guano		G.†				*2.40*			*10.00*	*2.00*
			G.†				*1.60*			*10.00*	*2.00*
A 3707	Sunrise Guano	Birmingham	F.†	1.04	0.22	0.28	1.54	13.10	1.52	11.58	2.12
			G.†							*16.00*	
A 4496	16% Acid Phosphate	Brighton	F.†					17.80	0.68	17.12	
A 3983*	16% Acid Phosphate	Burnip Corners						16.80	0.74	16.06	
A 3997*	16% Acid Phosphate	Grand Rapids						16.20	0.82	15.38	
		Average						16.93	0.75	16.18	
			G.†				*0.82*			*8.00*	*3.00*
A 4010	Big Harvest Brand	Grand Rapids	F.†	0.59	0.18	0.24	1.01	10.40	1.24	9.16	3.20
A 4225	Big Harvest Brand	Jackson		0.60	0.19	0.20	0.99	10.60	1.20	9.40	3.36
A 4328	Big Harvest Brand	St. Johns		0.74	0.19	0.18	1.11	9.20	1.24	7.96	3.03
A 4348	Big Harvest Brand	Montrose		0.51	0.20	0.17	0.88	12.65	1.14	11.51	2.52
A 3987*	Big Harvest Brand	Burnip Corners		0.79	0.19	0.10	1.08	11.00	2.26	8.74	3.00
A 3994*	Big Harvest Brand	Coopersville		0.80	0.21	0.14	1.15	11.15	2.24	8.91	3.00
A 4567*	Big Harvest Brand	Grand Blanc		0.82	0.18	0.10	1.10	10.85	1.68	9.17	3.01
		Average		0.69	0.19	0.16	1.04	10.83	1.57	9.26	3.02
			G.†							*10.00*	*5.00*
A 4007	Big Potash	Grand Rapids	F.†					13.05	2.66	10.39	5.11
A 3820	Big Potash	Hudsonville						13.40	1.52	11.88	4.33
A 4045	Big Potash	Hudsonville						11.80	1.82	9.98	5.34
A 4353	Big Potash	Grand Blanc						12.10	1.78	10.32	4.98
A 4102*	Big Potash	Sparta						11.10	0.66	10.44	5.18
A 4565*	Big Potash	Grand Blanc						11.60	0.68	10.92	4.32
		Average						12.17	1.52	10.65	4.88

†Abbreviations for Guaranteed and Found.
*Fall Samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Darling & Company—Cont.										
			G.†	....	....	....	*0.82*	....	....	*12.00*	....
A 3919	Bone and Acid Phosphate Half and Half	Bangor	F.†	0.80	0.54	0.15	1.49	20.70	8.65	12.05	....
A 4006	Bone and Acid Phosphate Half and Half	Grand Rapids		0.61	0.84	0.33	1.78	25.55	14.42	**11.13**	....
A 4273	Bone and Acid Phosphate Half and Half	Hudson		0.66	0.30	0.12	1.08	23.00	10.65	12.35	....
A 4000*	Bone and Acid Phosphate Half and Half	Grand Rapids		0.75	0.44	0.29	1.48	23.95	12.20	**11.75**	....
A 4104*	Bone and Acid Phosphate Half and Half	Sparta		0.57	0.45	0.31	1.33	22.73	10.45	12.28	....
		Average		0.68	0.51	0.24	1.43	23.18	11.27	11.91	....
			G.†	....	....	....	*1.65*	....	....	*8.00*	*2.00*
A 4008	Chicago Brand	Grand Rapids	F.†	1.25	0.31	0.22	1.78	10.55	1.42	9.13	2.27
A 4229	Chicago Brand	St. Johns		1.23	0.23	0.16	1.62	11.90	1.62	10.28	1.97
A 3984*	Chicago Brand	Burnips Corners		1.33	0.23	0.15	1.71	10.65	0.76	9.89	2.36
		Average		1.27	0.26	0.17	1.70	11.03	1.26	9.77	2.20
			G.†	....	....	....	*2.47*	....	....	*8.00*	*1.00*
A 4505	Farmers Favorite	Bad Axe	F.†	1.66	0.43	0.37	2.46	10.63	2.20	8.43	1.01
			G.†	....	....	....	*1.65*	....	....	*12.00*	....
A 4084	General Crop	Galien	F.†	0.54	0.58	0.49	1.61	15.20	2.44	12.76	....
			G.†	....	....	....	*0.82*	....	....	*9.00*	*1.00*
A 4009	Grain Grower	Grand Rapids	F.†	0.49	0.19	0.19	0.87	11.55	1.12	10.43	1.08
A 4226	Grain Grower	Stockbridge		0.47	0.21	0.23	0.91	11.20	1.18	10.02	1.16
A 4310	Grain Grower	Reading		0.65	0.18	0.19	1.02	12.45	1.62	10.83	1.09
A 3985*	Grain Grower	Burnips Corners		0.63	0.28	0.11	1.02	11.30	0.92	10.38	1.16
A 4519*	Grain Grower	Davison		0.55	0.23	0.08	0.86	13.20	1.08	12.12	1.00
A 4533*	Grain Grower	Utica		0.83	0.27	0.07	1.17	11.80	1.74	10.06	1.36
		Average		0.60	0.23	0.14	0.97	11.92	1.28	10.64	1.14
			G.†	....	....	....	*0.82*	....	....	*10.00*	....
A 3887	Little Giant	Nunica	F.†	0.39	0.24	0.21	0.84	13.85	1.28	12.57	....
A 4552*	Little Giant	Richmond		0.56	0.35	0.11	1.02	12.70	1.76	10.94	....
A 4566*	Little Giant	Grand Blanc		0.48	0.34	0.08	0.90	13.45	2.98	10.47	....
		Average		0.47	0.31	0.14	0.92	13.34	2.01	11.33	....

			G.†	...	...	...	*2.06*	*1.00*	...	...	*1.00*
A 4025	Pulverized Sheep Manure	Grand Rapids	F.†	0.70	0.42	1.07	2.19	2.40	0.66	1.74	1.37
A 4079	Pulverized Sheep Manure	Niles		0.48	0.43	1.09	2.00	1.85	0.12	1.73	3.60
		Average		0.59	0.43	1.08	2.10	2.13	0.39	1.74	2.49
			G.†	...	...	...	*1.85*	*28.00*	...	...	...
A 4011	Pure Ground Bone	Grand Rapids	F.†	0.96	1.00	0.57	2.53	28.60	...	...	...
A 4103*	Pure Ground Bone	Sparta		0.69	1.05	0.65	2.39	28.10	...	...	...
		Average		0.83	1.02	0.61	2.46	28.35	...	...	...
			G.†	...	...	...	*0.82*	...	...	*10.00*	*0.50*
A 3930	Sure Winner	Grand Rapids	F.†	0.58	0.21	0.22	1.04	13.40	1.74	11.66	0.76
A 4434	Sure Winner	Linden		0.43	0.23	0.25	0.91	13.05	1.76	11.29	0.71
A 4462	Sure Winner	Britton		0.45	0.21	0.21	0.87	13.05	1.50	11.55	0.83
A 3986*	Sure Winner	Burnips Corners		0.51	0.25	0.17	0.93	13.60	2.00	11.60	0.74
A 4534*	Sure Winner	Utica		0.52	0.24	0.21	0.97	12.95	2.04	10.91	0.83
		Average		0.50	0.23	0.21	0.94	13.21	1.81	11.40	0.77
	Federal Chemical Co., Louisville, Ky.										
			G.†	...	...	...	*0.82*	...	...	*12.00*	...
A 4113*	A-1 Fertilizer	Conklin	F.†	0.62	0.21	0.04	0.87	13.10	0.94	12.16	...
			G.†	...	...	...	*1.65*	...	...	*10.00*	...
A 4178*	A-1 Formula	Wayland	F.†	0.94	0.31	0.11	1.36	11.75	1.46	10.29	...
			G.†	...	...	...	...	...	...	...	*14.00*
A 3916	Alsatian Potash	Hartford	F.†	...	...	...	...	...	...	...	14.16
			G.†	...	...	...	...	...	...	*12.00*	*4.00*
A 4022	Black Land Special	Grand Rapids	F.†	...	...	...	...	13.92	0.72	13.20	4.02
A 4053	Black Land Special	Zeeland		...	...	...	...	13.10	0.82	12.28	4.19
A 4097	Black Land Special	St. Joseph		...	...	...	...	12.35	0.86	11.54	4.22
A 4176*	Black Land Special	Lowell		...	...	...	...	13.90	1.34	12.56	3.94
A 4541*	Black Land Special	New Haven		...	...	...	...	13.60	1.28	12.32	3.21
		Average		...	...	...	...	13.38	1.00	12.38	3.92
			G.†	...	...	...	*0.82*	...	...	*11.00*	*3.00*
A 4373	Braden Formula	Ridgeway	F.†	0.65	0.13	0.12	0.90	12.00	0.70	11.30	3.01
A 4175*	Braden Formula	Chesaning		0.81	0.07	0.11	0.99	12.65	1.02	11.63	3.10
		Average		0.73	0.10	0.12	0.95	12.32	0.86	11.46	3.05
			G.†	...	...	...	...	...	...	*8.00*	*2.00*
A 4540*	Daybreak Champion Potash Fertilizer	New Haven	F.†	...	...	...	...	14.20	5.40	8.80	1.32
A 4686*	Daybreak Champion Potash Fertilizer	Sheldon		...	...	...	...	16.35	8.35	8.00	2.06
		Average		...	...	...	...	15.27	6.87	8.40	1.69

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Federal Chemical Co.—Cont.										
			G.†				*0.82*			*11.00*	*3.00*
A 4330	Daybreak Favorite	St. Johns	F.†	0.81	0.10	0.10	1.01	12.38	1.21	11.17	3.42
A 4147*	Daybreak Favorite	Imlay City		0.64	0.07	0.10	0.81	12.20	0.72	11.48	3.00
		Average		0.73	0.08	0.10	0.91	12.29	0.96	11.33	3.21
	Globe Tip Top Potash Fertilizer		*G.*†							*8.00*	*2.00*
			G.†				*1.65*			*10.00*	
A 4371	Half and Half Meal Mixture	Vernon	F.†	0.94	0.32	0.19	1.45	18.60	7.05	11.55	
			G.†				*1.65*			*12.00*	
A 4041	High Grade Fertilizer	Grand Rapids	F.†	1.05	0.22	0.00	1.27	15.15	0.61	11.51	
A 4372	High Grade Fertilizer	Louisville		0.93	0.26	0.13	1.32	14.50	0.82	13.68	
A 4601*	High Grade Fertilizer	Marshall		1.10	0.34	0.17	1.61	13.45	1.50	11.99	
A 4687*	High Grade Fertilizer	Sheldon		1.10	0.38	0.08	1.56	14.80	1.00	13.80	
		Average		1.01	0.30	0.10	1.44	14.48	0.99	13.49	
			G.†							*16.00*	
A 3762	High Grade Phosphate	Blissfield	F.†					19.40	2.64	16.76	
A 4024	High Grade Phosphate	Grand Rapids						18.80	0.46	18.41	
A 4052	High Grade Phosphate	Zeeland						18.50	1.34	17.16	
A 4098	High Grade Phosphate	St. Joseph						18.75	2.04	16.71	
A 3993*	High Grade Phosphate	Coopersville						19.10	0.86	18.24	
A 4120*	High Grade Phosphate	Zeeland						17.95	1.08	16.87	
A 4522*	High Grade Phosphate	Clinton						18.35	0.76	17.59	
A 4537*	High Grade Phosphate	New Haven						17.95	0.78	17.17	
A 4572*	High Grade Phosphate	Vernon						18.25	0.76	17.49	
		Average						18.57	1.19	17.38	
			G.†				*0.41*			*10.00*	
A 4172*	Liberty Grain Grower	Capac	F.†	0.21	0.12	0.09	0.42	16.45	2.78	13.67	

			G.†	....	....	....	*1.65*	....	....	*12.00*	*2.00*
A 4259	Loam Land Fertilizer	Clayton	F.†	1.28	0.20	0.20	1.68	13.13	2.01	**11.12**	2.34
A 4141*	Loam Land Fertilizer	Birch Run		0.56	0.13	0.12	**0.81**	13.50	1.36	12.14	**1.21**
A 4685*	Loam Land Fertilizer	Dearborn		1.12	0.17	0.05	**1.34**	13.50	0.90	12.60	2.02
		Average		0.99	0.16	0.12	**1.27**	13.37	1.42	11.95	**1.86**
			G.†	....	....	....	*0.41*	....	....	*11.00*	*1.00*
A 3724	Michigan Bean and Beet Special	Wayne	F.†	0.12	0.10	0.12	0.34	13.30	0.62	12.68	1.00
A 4260	Michigan Bean and Beet Special	Clayton		0.28	0.10	0.04	0.42	12.55	0.60	11.95	0.97
A 4375	Michigan Bean and Beet Special	Ridgeway		0.93	0.13	0.14	1.20	14.10	1.22	12.88	1.02
A 4108*	Michigan Bean and Beet Special	Zeeland		0.22	0.12	0.08	0.42	12.50	1.26	11.24	0.70
A 4122*	Michigan Bean and Beet Special	Zeeland		0.36	0.15	0.16	0.67	13.30	0.82	12.48	1.03
		Average		0.38	0.12	0.11	0.61	13.15	0.90	12.25	0.94
			G.†	....	....	....	*1.65*	....	....	*10.00*	*4.00*
A 3878	Mid West High Grade Mixture	Lowell	F.†	1.62	0.07	0.17	1.86	10.55	0.85	**9.70**	3.96
A 3899	Mid West High Grade Mixture	Kalamazoo		1.24	0.04	0.10	**1.38**	11.60	0.95	10.65	**3.86**
A 4600*	Mid West High Grade Mixture	Marshall		0.68	0.10	0.18	**0.96**	12.95	1.72	11.23	**3.74**
		Average		1.18	0.07	0.15	**1.40**	11.70	1.17	10.53	**3.85**
	Mogul Potash Fertilizer	....	G.†	....	....	....	....	....	....	*8.00*	*2.00*
	Nitro-Phosphate	....	G.†	....	....	....	*0.41*	....	....	*15.00*	....
			G.†	....	....	....	....	....	....	*10.00*	*2.00*
A 3761	Potash Special	Blissfield	F.†	....	....	....	....	11.40	0.72	10.68	1.98
A 3879	Potash Special	Lowell		....	....	....	....	12.85	0.84	12.01	3.75
A 4054	Potash Special	Zeeland		....	....	....	....	10.95	0.78	10.17	2.23
A 4245	Potash Special	Tecumseh		....	....	....	....	11.30	0.86	10.44	2.23
A 4109*	Potash Special	Zeeland		....	....	....	....	16.35	5.52	10.83	1.95
A 4121*	Potash Special	Zeeland		....	....	....	....	10.43	0.74	**9.69**	2.02
A 4539*	Potash Special	New Haven		....	....	....	....	10.85	0.85	10.00	**1.55**
A 4574*	Potash Special	Vernon		....	....	....	....	10.10	0.86	**9.24**	**1.48**
		Average		....	....	....	....	11.78	1.40	10.38	2.15
	Pure Bone	....	G.†	....	....	....	*1.00*	*30.00*	....	....	....
			G.†	....	....	....	....	....	....	*14.00*	....
A 4146*	Royal Phosphate	Imlay City	F.†	....	....	....	....	16.60	0.58	16.02	....
			G.†	....	....	....	*0.82*	....	....	*10.00*	*2.00*
A 4023	Special Manure	Grand Rapids	F.†	0.51	0.14	0.10	0.75	12.40	0.86	11.54	2.10
A 4376	Special Manure	Ridgeway		0.49	0.09	0.18	0.76	10.20	0.60	**9.60**	2.95
A 4573*	Special Manure	Vernon		0.67	0.13	0.08	0.88	11.10	0.72	10.38	2.02
		Average		0.55	0.12	0.12	0.79	11.23	0.73	10.50	2.36

†Abbreviations for guaranteed and found.
*Fall samples

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Federal Chemical Co.—Cont.										
A 3725	Special Phosphate Mixture	Wayne	*G.*†							*10.00*	
			F.†					22.70	7.12	15.58	
A 3828	Special Phosphate Mixture	Coopersville						24.90	8.25	16.65	
A 4246	Special Phosphate Mixture	Tecumseh						24.25	10.80	13.45	
		Average						23.95	8.72	15.23	
A 4174*	Standard Crop and Tobacco Grower	Chesaning	*G.*†				*0.82*			*8.00*	*4.00*
			F.†	0.63	0.09	0.09	0.81	9.30	0.64	8.66	**3.32**
	Standard Meal Mixture		*G.*†				*0.82*			*10.00*	
A 3760	Standard Wheat and Corn Maker	Blissfield	*G.*†				*0.41*			*11.50*	*0.50*
			F.†	0.17	0.12	0.10	0.39	12.70	1.26	11.44	0.61
A 4021	Standard Wheat and Corn Maker	Grand Rapids		0.23	0.14	0.13	0.50	19.20	7.77	11.43	0.68
A 4056	Standard Wheat and Corn Maker	Zeeland		0.19	0.13	0.07	0.39	13.00	1.16	11.84	0.52
A 4150*	Standard Wheat and Corn Maker	Marlette		0.24	0.11	0.07	0.42	13.30	0.88	12.42	0.62
		Average		0.21	0.12	0.09	0.42	14.55	2.77	11.78	0.61
A 3897	Wheat and Grain Special	Wayland	*G.*†				*0.82*			*12.00*	*1.00*
			F.†	0.40	0.09	0.30	0.79	13.90	0.90	13.00	1.02
A 3898	Wheat and Grain Special	Kalamazoo		0.65	0.09	0.06	0.80	14.70	1.45	13.25	1.20
A 3915	Wheat and Grain Special	Hartford		0.66	0.10	0.04	0.80	13.90	1.72	12.18	1.18
A 4130*	Wheat and Grain Special	Vermontville		0.61	0.12	0.08	0.81	16.80	4.40	12.40	1.55
A 4538*	Wheat and Grain Special	New Haven		0.68	0.14	0.11	0.93	12.33	0.86	**11.47**	1.30
		Average		0.60	0.11	0.12	0.83	14.33	1.87	12.46	1.25
A 4168*	10% Potash Fertilizer	Ruth	*G.*†							*6.00*	*10.00*
			F.†					12.50	5.50	7.00	**8.06**
	1st Prize Formula		*G.*†				*0.82*			*11.00*	*3.00*
	The Fertile Chemical Co., Cleveland, Ohio.										
	Nitro-Fertile		*G.*†				*2.00*			*3.00*	*3.00*
	Lime-Fertile		*G.*†					*3.00*			

	Gleaner Clearing House Assn., Grand Rapids, Mich.										
	14% Acid Phosphate		G.†							*14.00*	
			G.†							*16.00*	
A 4683*	16% Acid Phosphate	Swartz Creek	F.†					17.65	0.20	17.45	
			G.†				*1.65*			*10.00*	
A 4680*	Ammonia and Phosphoric Acid	Swartz Creek	F.†	1.03	0.35	0.16	1.54	12.70	0.58	12.12	
			G.†				*0.82*			*10.00*	*1.00*
A 4515	Bean and Corn Grower	Bridgeport	F.†	0.64	0.34	0.19	1.17	14.85	0.98	13.87	0.00
A 4678*	Bean and Corn Grower	Swartz Creek		0.51	0.17	0.13	0.81	11.65	0.34	11.31	1.36
		Average		0.57	0.26	0.16	0.99	13.25	0.66	12.59	0.68
			G.†				*0.82*			*8.00*	*1.00*
A 4514	General Grower	Bridgeport	F.†	0.43	0.37	0.22	1.02	9.90	1.20	8.70	1.00
A 4179*	General Grower	Ionia		0.54	0.25	0.09	0.88	9.55	0.60	8.95	1.01
A 4679*	General Grower	Swartz Creek		0.52	0.24	0.11	0.87	9.30	0.62	8.68	1.09
		Average		0.49	0.29	0.14	0.92	9.58	0.81	8.77	1.03
			G.†				*1.65*			*8.00*	*1.00*
A 4181*	Grain Grower	Ionia	F.†	1.09	0.41	0.17	1.67	10.20	0.82	9.38	1.08
A 4681*	Grain Grower	Swartz Creek		0.99	0.43	0.22	1.64	12.50	0.70	11.80	0.93
		Average		1.04	0.42	0.20	1.66	11.35	0.76	10.59	1.00
			G.†				*1.65*			*10.00*	*1.00*
A 4682*	Grain Special	Swartz Creek	F.†	0.89	0.33	0.13	1.35	13.10	0.54	12.56	1.59
			G.†							*10.00*	*2.00*
A 4677*	Phosphoric Acid and Potash	Swartz Creek	F.†					11.35	0.35	11.00	1.85
			G.†				*0.82*			*8.00*	*2.00*
A 4513	Wolverine Pride	Bridgeport	F.†	0.48	0.29	0.20	0.97	9.15	0.94	8.21	1.96
A 4180	Wolverine Pride	Ionia		1.18	0.33	0.15	1.66	10.20	0.64	9.56	1.55
		Average		0.83	0.31	0.17	1.31	9.67	0.79	8.88	1.75
	International Agricultural Corp., Buffalo, N. Y.										
	Buffalo Brands										
			G.†							*10.00*	*4.00*
A 3819	Acid and Potash	Grand Rapids	F.†					14.90	2.56	12.34	3.37
A 3991*	Acid and Potash	Hudsonville						11.45	0.44	11.01	3.71
		Average						13.17	1.50	11.67	3.54

†Abbreviations for guaranteed and found.
*Fall Samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1920 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	International Agricultural Corp.—Cont.										
	Buffalo Brands										
			G.†	....	....	....	*1.60*	....	....	*12.00*	....
A 3823	Ammoniated Phosphate	Zeeland	F.†	1.10	0.44	0.13	1.67	15.65	1.98	13.67	....
A 4583*	Ammoniated Phosphate	Eaton Rapids		1.26	0.17	0.12	1.55	15.50	2.56	12.94	....
		Average		1.18	0.30	0.13	1.61	15.57	2.27	13.30	....
			G.†	....	....	....	*1.60*	....	....	*12.00*	*2.00*
A 4595*	Crop Producer	Quincy	F.†	1.11	0.38	0.38	1.87	13.25	0.68	12.57	2.02
A 4646*	Crop Producer	Hillsdale		1.43	0.10	0.10	1.63	16.00	2.70	13.30	2.00
		Average		1.27	0.24	0.24	1.75	14.62	1.69	12.93	2.01
			G.†	....	....	....	....	....	....	*14.00*	....
A 4487	Dissolved Phosphate	Port Huron	F.†	....	....	....	....	15.90	0.48	15.42	....
			G.†	....	....	....	*1.60*	....	....	*8.00*	*2.00*
A 3821	Economy	Zeeland	F.†	1.15	0.31	0.17	1.63	11.55	2.60	8.95	2.21
A 3939	Economy	Holton		0.82	0.49	0.32	1.63	10.10	1.88	8.22	2.38
A 4597*	Economy	Quincy		0.89	0.43	0.38	1.70	10.50	0.76	9.74	1.99
		Average		0.95	0.41	0.29	1.65	10.72	1.75	8.97	2.19
			G.†	....	....	....	*0.80*	....	....	*10.00*	*2.00*
A 4502	Farmers Choice	Bach	F.†	0.66	0.13	0.09	0.88	13.70	2.62	11.08	2.02
			G.†	....	....	....	*0.80*	....	....	*8.00*	*1.00*
A 4267	General Favorite	Clayton	F.†	0.90	0.08	0.07	1.05	10.70	2.10	8.60	1.10
A 4436	General Favorite	Fenton		0.41	0.09	0.09	0.59	11.50	3.00	8.50	1.03
A 4466	General Favorite	Tecumseh		0.83	0.08	0.06	0.97	11.20	2.40	8.80	1.27
A 3990*	General Favorite	Hudsonville		0.21	0.39	0.37	0.97	9.25	0.46	8.79	1.10
A 4562*	General Favorite	Fenton		0.60	0.04	0.23	0.87	9.95	1.20	8.75	1.07
		Average		0.59	0.14	0.16	0.89	10.52	1.83	8.69	1.11

			G.†	....	....	....	....	....	....	*18.00*	....
A 4542*	High Grade Acid Phosphate 18%	New Haven	F.†	....	....	....	....	19.50	0.40	19.10	....
			G.†	....	....	....	*1.60*	....	....	*10.00*	*4.00*
A 3928	Ideal Wheat and Corn	Marshall	F.†	0.71	0.54	0.22	**1.47**	12.05	1.16	10.89	4.00
A 3940	Ideal Wheat and Corn	Holton		0.74	0.39	0.27	**1.40**	11.80	0.98	10.82	4.29
A 4465	Ideal Wheat and Corn	Tecumseh		1.23	0.21	0.16	1.60	13.05	1.80	11.25	4.37
A 4647*	Ideal Wheat and Corn	Hillsdale		1.38	0.10	0.11	1.59	15.65	2.98	12.67	**2.06**
		Average		1.02	0.31	0.19	1.52	13.14	1.73	11.41	**3.68**
			G.†	....	....	....	*2.50*	....	....	*8.00*	*3.00*
A 3822	Onion, Vegetable and Potato	Zeeland	F.†	2.23	0.23	0.14	2.70	11.40	2.54	8.86	**1.41**
A 3989*	Onion, Vegetable and Potato	Hudsonville		0.27	0.33	0.34	**0.94**	9.35	0.48	8.87	3.68
		Average		1.30	0.28	0.24	**1.82**	10.37	1.51	8.86	**2.54**
			G.†	....	....	....	....	....	....	*12.00*	*2.00*
A 3818	Phosphate and Potash	Grand Rapids	F.†	....	....	....	....	16.20	2.94	13.26	2.10
A 3587	Phosphate and Potash	Caledonia		....	....	....	....	17.40	3.22	14.08	**1.66**
A 4440	Phosphate and Potash	Northville		....	....	....	....	13.50	0.40	13.10	1.96
A 4543*	Phosphate and Potash	New Haven		....	....	....	....	15.20	1.42	13.78	2.02
		Average		....	....	....	....	15.55	1.99	13.56	1.94
			G.†	....	....	....	....	....	....	*16.00*	....
A 3817	Sixteen Percent	Grand Rapids	F.†	....	....	....	....	19.06	1.66	17.40	....
A 4435	Sixteen Percent	Fenton		....	....	....	....	19.80	2.00	17.80	....
A 4467	Sixteen Percent	Tecumseh		....	....	....	....	18.90	1.04	17.86	....
A 4596*	Sixteen Percent	Quincy		....	....	....	....	17.05	0.30	16.75	....
		Average		....	....	....	....	18.70	1.25	17.45	....
			G.†	....	....	....	*0.80*	*22.00*	....	....	....
A 4268	Special Wheat Fertilizer	Clayton	F.†	0.68	0.24	0.13	1.05	23.00	....	....	....
			G.†	....	....	....	*2.50*	....	....	*8.00*	*1.00*
A 3964	Three Eight One	Allegan	F.†	0.94	0.77	0.72	2.43	9.23	1.51	**7.72**	1.11
A 4582*	Three Eight One	Eaton Rapids		2.04	0.26	0.13	2.43	10.55	2.06	8.49	1.16
		Average		1.49	0.51	0.43	2.43	9.89	1.78	8.11	1.13
			G.†	....	....	....	*0.80*	....	....	*8.00*	*4.00*
A 3965	Tip Top	Allegan	F.†	0.23	0.35	0.35	0.93	9.05	0.58	8.47	4.39
A 4446	Tip Top	Belleville		0.42	0.29	0.19	0.90	8.65	1.45	**7.20**	4.35
A 4495	Tip Top	Romulus		0.59	0.19	0.09	0.87	11.30	2.80	8.50	**3.86**
A 3988*	Tip Top	Hudsonville		0.90	0.93	0.71	2.54	9.35	0.60	8.75	**2.75**
		Average		0.54	0.44	0.33	1.31	9.59	1.36	8.23	**3.84**

†Abbreviations for guaranteed and found.
*Fall Samples

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	International Agricultural Corp.—Cont										
	I. A. C. Brands										
			G.†	....	....	....	....	....	....	*16.00*	....
A 3906	Acid Phosphate	Marcellus	F.†	....	....	....	....	20.60	3.04	17.56	....
A 4464	Acid Phosphate	Britton		....	....	....	....	19.70	1.96	17.74	....
		Average		....	....	20.15	2.50	17.65	....	....	....
			G.†	....	....	....	....	....	....	*12.00*	*2.00*
A 4441	Alkaline	Northville	F.†	....	....	....	....	11.83	1.90	**9.93**	3.16
			G.†	....	....	....	*1.60*	....	....	*8.00*	*2.00*
A 3862	Complete	Charlotte	F.†	1.42	0.27	0.12	1.81	11.30	3.00	8.30	2.02
A 3911	Complete	Dowagiac		1.26	0.26	0.16	1.68	11.10	2.22	8.88	2.20
A 3925	Complete	Marshall		0.80	0.45	0.39	1.64	9.60	1.52	8.08	1.94
A 4602*	Complete	Eaton Rapids		1.16	0.29	0.12	1.59	13.00	4.43	8.57	2.17
		Average		1.16	0.32	0.20	1.68	11.25	2.79	8.46	2.08
			G.†	....	....	....	*1.60*	....	....	*12.00*	....
A 3909	Corn and Grain	Marcellus	F.†	0.92	0.40	0.11	**1.43**	15.70	1.88	13.82	....
A 3927	Corn and Grain	Marshall		0.68	0.55	0.21	**1.44**	13.90	1.20	12.70	....
A 4512	Corn and Grain	Parma		1.01	0.43	0.15	1.59	15.30	1.78	13.52	....
A 4640*	Corn and Grain	Maybee		1.30	0.27	0.17	1.74	17.25	5.13	12.12	....
		Average		0.98	0.41	0.16	1.55	15.53	2.49	13.04	....
			G.†	....	....	....	*1.60*	....	....	*12.00*	*2.00*
A 4641*	Crop Producer	Maybee	F.†	1.42	0.08	0.09	1.59	15.55	2.78	12.77	2.06
			G.†	....	....	....	*0.80*	....	....	*10.00*	....
A 3824	General Crop	Zeeland	F.†	0.79	0.30	0.16	1.25	14.50	2.00	12.50	....
			G.†	....	....	....	....	....	....	*18.00*	....
A 4603*	High Grade Acid Phosphate 18%	Eaton Rapids	F.†	....	....	....	....	19.85	0.80	19.05	....
			G.†	....	....	....	*0.80*	....	....	*8.00*	*4.00*
A 3863	One Eight Four	Charlotte	F.†	0.60	0.20	0.17	0.97	11.50	2.74	8.76	4.35

			G.†	....	....	....	*0.80*	....	....	*10.00*	*2.00*
A 3865	One Ten Two	Charlotte	F.†	0.71	0.17	0.11	0.99	13.35	3.04	10.31	2.83
A 4604*	One Ten Two	Eaton Rapids		0.77	0.08	0.12	0.97	12.80	2.70	10.10	2.47
		Average		0.74	0.12	0.12	0.98	13.07	2.87	10.20	2.65
			G.†	....	....	....	*2.50*	....	....	*8.00*	*3.00*
A 3908	Potato and Vegetable	Marcellus	F.†	1.85	0.34	0.12	**2.31**	10.00	1.66	8.34	3.27
A 4510	Potato and Vegetable	Parma		1.51	0.26	0.20	**1.97**	10.65	2.57	8.08	**1.31**
		Average		1.68	0.30	0.16	**2.14**	10.33	2.12	8.21	**2.29**
	Steamed Bone		G.†	....	....	....	*0.80*	*29.00*	....	....	....
			G.†	....	....	....	*2.50*	....	....	*8.00*	*1.00*
A 3907	Three Eight One	Marcellus	F.†	1.88	0.25	0.07	**2.20**	11.35	2.68	8.67	1.09
A 3926	Three Eight One	Marshall		0.85	0.96	0.33	**2.14**	9.85	1.00	8.85	1.74
		Average		1.37	0.60	0.20	**2.17**	10.60	1.84	8.76	1.41
			G.†	....	....	....	*0.80*	....	....	*8.00*	*1.00*
A 3929	Victory	Marshall	F.†	0.35	0.33	0.27	0.95	9.30	0.78	8.52	1.42
A 4442	Victory	Belleville		0.49	0.18	0.17	0.84	11.95	2.76	9.19	0.97
A 4463	Victory	Britton		0.72	0.06	0.05	0.83	11.15	2.98	8.17	1.06
		Average		0.52	0.19	0.16	0.87	10.80	2.17	8.63	1.15
			G.†	....	....	....	*0.80*	*22.00*	....	....	....
A 3864	Wheat Special	Charlotte	F.†	0.35	0.45	0.15	0.95	24.00	....	....	....
A 3910	Wheat Special	Marcellus		0.35	0.43	0.17	0.95	23.60	....	....	....
		Average		0.35	0.44	0.16	0.95	23.80	....	....	....
	The Jarecki Chemical Co., Sandusky, Ohio										
			G.†	....	....	....	....	....	....	*16.00*	....
A 4049	Acid Phosphate	Hudsonville	F.†	....	....	....	....	17.90	0.46	17.44	....
A 4242	Acid Phosphate	Manchester		....	....	....	....	17.20	0.78	16.42	....
A 4325	Acid Phosphate	North Adams		....	....	....	....	17.40	1.12	16.28	....
A 4327	Acid Phosphate	North Adams		....	....	....	....	18.10	0.44	17.66	....
		Average		....	....	....	....	17.65	0.70	16.95	....
			G.†	....	....	....	*1.65*	....	....	*12.00*	....
A 4048	Clay Soil Special	Hudsonville	F.†	1.22	0.44	0.02	1.68	14.50	1.34	13.16	....
A 4650*	Clay Soil Special	Litchfield		1.15	0.40	0.06	1.61	14.65	1.86	12.79	....
		Average		1.18	0.42	0.04	1.64	14.57	1.60	12.97	....

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at	Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	The Jarecki Chemical Co.—Cont.									
		G.†							*14.00*	
A 4386	C. O. D. Phosphate	Ida F.†					16.10	0.92	15.18	
A 4420	C. O. D. Phosphate	Deerfield					16.55	1.24	15.31	
		Average					16.32	1.08	15.24	
		G.†				*0.82*			*11.00*	*1.00*
A 3854	Lake Erie Guano with Phosphate	Sparta F.†	0.42	0.22	0.19	0.83	14.00	1.80	12.20	1.29
A 4240	Lake Erie Guano with Phosphate	Manchester	0.45	0.23	0.16	0.84	12.95	1.50	11.45	1.14
A 4270	Lake Erie Guano with Phosphate	Hudson	0.49	0.19	0.12	0.80	13.45	1.42	12.03	1.39
A 4307	Lake Erie Guano with Phosphate	Osseo	0.55	0.20	0.08	0.83	13.15	1.08	12.07	1.32
		Average	0.48	0.21	0.13	0.82	13.39	1.45	11.94	1.28
		G.†				*0.41*			*10.00*	*1.00*
A 3752	Little Giant	Blissfield F.†	0.36	0.08	0.07	0.51	10.55	1.24	**9.31**	**0.80**
A 3853	Little Giant	Sparta	0.22	0.07	0.13	0.42	11.45	1.46	9.99	**0.44**
A 4239	Little Giant	Manchester	0.30	0.07	0.08	0.45	11.13	1.30	9.83	**0.75**
A 4269	Little Giant	Hudson	0.21	0.09	0.11	0.41	11.20	1.14	10.06	**0.57**
		Average	0.27	0.08	0.10	0.45	11.08	1.28	9.80	**0.64**
		G.†				*1.65*			*12.00*	*2.00*
A 4279	Middle West Formula	Manitou Beach F.†	1.39	0.34	0.10	1.83	13.48	2.42	**11.06**	1.99
A 4324	Middle West Formula	North Adams	1.38	0.18	0.04	1.60	13.30	2.48	**10.82**	**1.70**
		Average	1.38	0.26	0.07	1.71	13.39	2.45	**10.94**	**1.85**
	Special Sugar Beet Grower	G.†				*0.41*			*10.00*	*1.00*
		G.†							*10.00*	*4.00*
A 4047	Super Phosphate and Potash	Hudsonville F.†					11.30	1.22	10.08	**3.75**
A 4448	Super Phosphate and Potash	Milan					12.05	1.26	10.79	4.12
A 4482	Super Phosphate and Potash	Memphis					10.68	1.83	**8.85**	4.23
A 4156*	Super Phosphate and Potash	Reese					11.65	1.86	**9.79**	4.04
		Average					11.42	1.54	9.88	4.03

			G.†				*0.82*			*8.00*	*2.00*
A 3856	Tobacco and Truck Grower	Dutton	F.†	0.63	0.14	0.11	0.88	8.23	1.06	**7.17**	**1.21**
A 3872	Tobacco and Truck Grower	Woodbury		0.72	0.08	0.13	0.93	9.45	1.68	**7.77**	**1.63**
A 4241	Tobacco and Truck Grower	Manchester		0.61	0.19	0.08	0.88	9.30	1.00	8.30	**1.85**
A 4309	Tobacco and Truck Grower	Reading		0.64	0.15	0.07	0.86	9.38	1.59	**7.79**	**1.68**
		Average		0.65	0.14	0.09	0.88	9.09	1.33	**7.76**	**1.59**
			G.†				*0.82*			*9.00*	*7.00*
A 4046	Truck Special	Hudsonville	F.†	0.72	0.07	0.07	0.86	10.18	1.36	8.82	**6.30**
	Natural Guano Co., Aurora, Ill.										
	Sheep's Head Pulverized Sheep Manure		G.†				*2.25*			*1.00*	*1.50*
	Nitrate Agencies Co., Columbus, Ohio										
	NaCo Nitrate of Soda		G.†				*15.00*				
	Pacific Manure & Fertilizer Co., San Francisco, Cal.										
			G.†				*1.84*			*0.75*	*3.00*
A 4026	Groz-it Brand Pulverized Sheep Manure	Grand Rapids	F.†	0.35	0.37	0.82	**1.54**	1.20	0.16	1.04	2.95
A 4057	Groz-it Brand Pulverized Sheep Manure	Kalamazoo		0.40	0.32	0.80	**1.52**	0.90	0.18	0.72	3.23
		Average		0.38	0.34	0.81	**1.53**	1.05	0.17	0.88	3.09
	Parke Davis & Co., Detroit, Mich.										
	Parkedale Fertilizer		G.†				*7.00*			*0.60*	*0.40*
	Packers Fertilizer Co., Sandusky, Ohio										
			G.†							*16.00*	
A 4429	Acid Phosphate	Saline	F.†					15.90	2.91	**12.99**	
A 4618*	Acid Phosphate	Saline						17.35	0.90	16.45	
		Average						16.62	1.90	**14.72**	
			G.†							*14.00*	
A 3829	Acidulated Phosphate	Coopersville	F.†					18.30	0.42	17.88	
			G.†				*1.65*			*12.00*	
A 3885	Clay Soil Special	Holland	F.†	1.31	0.46	0.06	1.83	14.25	1.70	12.55	
A 4423	Clay Soil Special	Deerfield		1.24	0.40	0.10	.174	14.65	1.46	13.19	
		Average		1.27	0.43	0.08	1.78	14.45	1.58	12.87	
			G.†							*10.00*	*1.00*
A 4443	O. K. Fertilizer	Willis	F.†	0.32	0.07	0.07	0.46	11.75	1.72	10.03	**0.79**
A 4457	O. K. Fertilizer	Carleton		0.31	0.08	0.09	0.48	11.65	1.56	10.09	**0.69**
		Average		0.31	0.08	0.08	0.47	11.70	1.64	10.06	**0.74**

†Abbreviation for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Packers Fertilizer Co.—Cont.										
			G.†				*0.41*			*12.00*	
A 4385	Phosphate with Humus	Ida	F.†	0.28	0.13	0.07	0.48	13.80	2.71	**11.09**	
A 4422	Phosphate with Humus	Deerfield		0.26	0.11	0.09	0.46	13.80	2.49	**11.31**	
		Average		0.27	0.12	0.08	0.47	13.80	2.60	**11.20**	
			G.†				*0.82*			*8.00*	*2.00*
A 4444	Potato, Tobacco and Truck Manure	Ypsilanti	F.†	0.49	0.17	0.07	0.73	10.15	1.74	8.41	**1.62**
A 4615*	Potato, Tobacco and Truck Manure	Saline		0.84	0.10	0.07	1.01	10.30	1.66	8.64	2.02
		Average		0.67	0.13	0.07	0.87	10.23	1.70	8.53	**1.82**
			G.†				*1.65*			*12.00*	*2.00*
A 4427	Quality Brand	Saline	F.†	1.48	0.18	0.14	1.80	13.95	3.75	**10.20**	**1.81**
A 4620*	Quality Brand	Saline		1.76	0.14	0.11	2.01	14.50	2.55	11.95	2.04
		Average		1.62	0.16	0.12	1.90	14.23	3.15	**11.08**	1.93
			G.†							*10.00*	*4.00*
A 4428	Super Phosphate and Potash	Saline	F.†					10.55	1.47	**9.08**	4.17
A 4625*	Super Phosphate and Potash	Saline						12.15	1.92	10.23	**3.73**
		Average						11.35	1.69	**9.66**	3.95
			G.†				*0.82*			*11.00*	*1.00*
A 3830	Sweepstakes	Coopersville	F.†	0.43	0.19	0.15	0.77	13.60	1.86	11.74	0.94
A 3884	Sweepstakes	Holland		0.50	0.22	0.15	0.87	13.10	1.44	11.66	1.22
A 4426	Sweepstakes	Saline		0.38	0.22	0.16	0.76	13.50	1.54	11.96	0.95
A 4619*	Sweepstakes	Saline		0.63	0.24	0.10	0.97	12.85	2.00	10.85	1.16
		Average		0.48	0.22	0.14	0.84	13.26	1.71	11.55	1.07
	The Pulverized Manure Co., Chicago, Ill.										
			G.†				*1.80*			*1.00*	*1.00*
A 3842	Wizard Brand Cattle Manure	Fennville	F.†	0.24	0.41	1.18	1.83	1.50	0.14	1.36	2.20
A 3950	Wizard Brand Cattle Manure	Zeeland		0.24	0.39	1.13	1.76	1.05	0.14	0.91	2.03
		Average		0.24	0.40	1.15	1.79	1.27	0.14	1.13	2.11

			G.†				1.80			1.00	1.00
A 3949	Wizard Brand Mixed Manure	Hudsonville	F.†	0.31	0.34	1.08	1.73	1.50	0.20	1.30	2.13
A 3951	Wizard Brand Mixed Manure	Zeeland		0.46	0.37	1.05	1.88	1.00	0.18	0.82	1.82
		Average		0.38	0.35	1.07	1.80	1.25	0.19	1.06	1.98
			G.†				1.80			1.00	1.00
A 4493	Wizard Brand Sheep Manure	Plymouth	F.†	0.50	0.41	1.01	1.92	1.35	0.14	1.21	2.05
	Wizard Brand Hog Manure		G.†				1.80			1.00	1.00
	The Queen City Fertilizer Co., Sandusky, Ohio										
	Special Sugar Beet Grower		G.†				0.82			8.00	1.00
	Rasin Monumental Co., Cincinnati, Ohio										
	10–4 Acid and Potash		G.†							10.00	4.00
	14% Acid Phosphate		G.†							14.00	
			G.†							16.00	
A 4691*	16% Acid Phosphate	Batavia	F.†					16.65	0.24	16.11	
			G.†							20.00	
A 4449	20% Acid Phosphate	Milan	F.†					22.30	0.14	22.16	
A 4183*	20% Acid Phosphate	Eau Claire						20.65	0.28	20.37	
A 4633*	20% Acid Phosphate	Milan						22.25	0.60	21.65	
		Average						21.73	0.34	21.39	
	Big Giant Phosphate		G.†				0.82			8.00	3.00
	Farmers Success		G.†				0.82			8.00	1.00
	Fenhumus Fertilizer		G.†				0.41			12.00	
			G.†				1.65			8.00	2.00
A 4690*	General Favorite	Batavia	F.†	1.15	0.27	0.31	1.73	9.95	1.20	8.75	2.24
	Grain Fertilizer		G.†				0.82			13.00	
	Phosphate and Bone Meal		G.†				0.82	22.00		10.00	
			G.†				0.82			8.00	2.00
A 4634*	Reliable Wheat and Corn Fertilizer	Milan	F.†	0.51	0.19	0.16	0.86	9.95	0.68	9.27	2.33
	Royal Giant Grower		G.†							12.00	2.00

†Abbreviations for guaranteed and found.
*Fall sample.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Rasin Monumental Co.—Cont.										
	Special Plant Food		G.†				*1.65*			*11.00*	
A 4184*	Sweepstakes Fertilizer	Eau Claire	G.†				*1.65*			*12.00*	*2.00*
			F.†	1.29	0.24	0.18	1.71	14.10	0.28	13.82	2.33
	Nitrate of Soda		G.†				*15.00*				
	Read Phosphate Company, New Albany, Ind.										
A 4497	Ten-Ten	Glendora	G.†							*10.00*	*10.00*
			F.†					11.75	1.99	9.76	10.11
	F. S. Royster Guano Co., Toledo, Ohio										
A[3712	16% Acid Phosphate	Washington	G.†							*16.00*	
			F.†					19.05	0.92	18.13	
A 3766	16% Acid Phosphate	Adrian						18.15	0.72	17.43	
A 3788	16% Acid Phosphate	Eaton Rapids						17.15	0.68	16.47	
A 4018	16% Acid Phosphate	Grand Rapids						18.53	0.78	17.75	
A 4063	16% Acid Phosphate	Portage						17.90	0.72	17.18	
A 4521*	16% Acid Phosphate	Rochester						18.45	0.88	17.57	
A 4557*	16% Acid Phosphate	Washington						18.55	0.68	17.87	
A 4579*	16% Acid Phosphate	Eaton Rapids						18.80	0.30	17.70	
		Average						18.22	0.71	17.51	
A 3894	Black Soil Guano	Conklin	G.†				*0.80*			*8.00*	*5.00*
			F.†	0.61	0.12	0.18	0.91	10.90	2.66	8.24	4.61
A 4064	Black Soil Guano	Portage		0.48	0.10	0.17	0.75	11.20	2.63	8.57	4.54
A 4248	Black Soil Guano	Tecumseh		0.56	0.10	0.14	0.80	10.40	1.98	8.42	4.75
		Average		0.55	0.11	0.16	0.82	10.83	2.42	8.41	4.63
A 3966	Bully Guano	Hopkins	G.†				*1.60*			*8.00*	*5.00*
			F.†	1.23	0.18	0.21	1.62	10.[illegible]0	1.20	9.00	4.99

			G.†	....	....	....	*0 80*	....	....	*8.00*	*1 00*
A 3731	Cuckoo Guano	Plymouth	F.†	0 51	0 14	0.21	0 86	10 15	1 86	8.29	1 00
A 3787	Cuckoo Guano	Eaton Rapids		0 48	0.12	0 23	0 83	9 85	1.79	8.06	1 08
A 3789	Cuckoo Guano	Springport		0.48	0 14	0.21	0.83	10 10	1.84	8 26	**0 85**
A 4032	Cuckoo Guano	Coopersville		0.46	0.14	0.15	0 75	9.70	1.66	8 04	1 00
		Average		0.48	0.13	0.20	0.81	9.95	1.79	8.16	0.98
			G.†	....	....	....	*1 60*	....	....	*10.00*	*4.00*
A 3815	Excello Guano	Grand Rapids	F.†	1.10	0 27	0.15	1.52	12.45	1.00	11.45	4.54
A 4581*	Excello Guano	Eaton Rapids		0.62	0 14	0.13	**0 89**	12 80	1 62	11.18	4.17
A 4612*	Excello Guano	Saline		1.10	0 28	0 22	1.60	13 10	1.90	11.20	4.56
		Average		0.94	0 23	0.17	**1.34**	12.78	1.51	11 27	4.42
			G.†	....	....	....	*1 60*	....	....	*10.00*	*2.00*
A 3959	Favorite Guano	Pullman	F.†	1.53	0 19	0.18	1.90	12.80	1.58	11.22	2.17
	Fifty-Fifty Bone and Phosphate		G.†	....	....	....	*1.20*	....	....	*13.00*	....
			G.†	....	....	....	*1.60*	....	....	*8.00*	*3.00*
A 4409	Fish, Flesh and Fowl Guano	Monroe	F.†	1.12	0 24	0 20	1 56	10.65	1.36	9.29	2.99
A 4134*	Fish, Flesh and Fowl Guano	Bellvue		1.04	0 29	0 30	1.63	11.45	2.38	9 07	3.11
		Average		1.08	0 27	0.25	1.60	11.05	1.87	9.18	3.05
			G.†	....	....	....	*2.40*	....	....	*10 00*	*2.00*
A 4068	Miracle Guano	Decatur	F.†	1.73	0 32	0 23	**2 28**	12 00	1.78	10 22	3 45
A 4404	Miracle Guano	Erie		1 66	0 32	0.13	**2.11**	11.90	0 94	10 96	2 52
		Average		1.69	0.32	0.18	**2 19**	11.95	1.36	10.59	2 98
			G.†	....	....	....	*1.60*	....	....	*12 00*	....
A 3816	Security Brand	Grand Rapids	F.†	1.21	0 38	0 28	1 87	15 05	2.22	12.83	....
A 4082	Security Brand	Buchanan		1 29	0 31	0 18	1.78	14 95	2.12	12.83	....
A 4317	Security Brand	Reading		1 27	0 27	0 10	1 64	14.75	1.74	13 01	....
A 4403	Security Brand	Erie		1 11	0 31	0 22	1 64	14 75	2 13	12.73	....
A 4592*	Security Brand	Quincy		1 27	0 32	0 24	1 83	14.60	2.38	12.22	....
		Average		1 23	0.32	0 20	1.75	14 82	2.10	12 72	....
			G.†	....	....	....	*0 80*	....	....	*11.00*	*2 00*
A 3791	Special Fish Guano	Springport	F.†	0 51	0.17	0 12	0.80	13 10	1 02	12 08	**1 81**
A 4249	Special Fish Guano	Tecumseh		0 50	0 21	0.10	0.81	13.40	0.90	12.50	2 21
A 4318	Special Fish Guano	Reading		0 61	0.17	0 10	0 88	12 95	1 78	11 17	1.98
A 4408	Special Fish Guano	Monroe		0 48	0.21	0 14	0 83	12.55	1 71	10 84	1.94
A 4610*	Special Fish Guano	Manchester		0.36	0 21	0.16	0.73	13.50	0 94	12.56	2 18
A 4160*	Special Fish Guano	Cass City		0 47	0.19	0.15	0 81	12.25	0.74	11.51	2.29
		Average		0 49	0.19	0 13	0 81	12.96	1 18	11 78	2.07

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	F. S. Royster Guano Co.—Cont.										
			G.†	....	....	....	*1.60*	....	....	*8.00*	*8.00*
A 3888	Supreme Guano	Nunica	F.†	1.27	0.22	0.17	1.66	10.25	1.26	8.99	**7.34**
A 4067	Supreme Guano	Decatur		1.17	0.23	0.19	1.59	10.75	1.02	9.73	9.17
A 4090	Supreme Guano	Sawyer		0.93	0.25	0.21	**1.39**	10.20	1.26	8.94	**6.50**
A 4254	Supreme Guano	Tecumseh		1.25	0.21	0.20	1.66	10.60	1.14	9.46	8.30
		Average		1.15	0.23	0.19	1.57	10.45	1.17	9.28	**7.83**
			G.†	....	....	....	*1.60*	....	....	*12.00*	*2.00*
A 3729	Vim Guano	Plymouth	F.†	1.34	0.22	0.08	1.64	14.75	1.28	13.47	2.19
A 3790	Vim Guano	Springport		1.23	0.19	0.20	1.62	14.85	1.32	13.53	**1.70**
A 3814	Vim Guano	Grand Rapids		1.22	0.26	0.25	1.73	14.80	0.86	13.94	2.16
A 4319	Vim Guano	Reading		1.23	0.25	0.13	1.61	13.80	0.78	13.02	2.08
A 4623*	Vim Guano	Saline		1.18	0.34	0.29	1.81	14.40	0.92	13.48	2.21
		Average		1.24	0.25	0.19	1.68	14.52	1.03	13.49	2.07
			G.†	....	....	....	*0.80*	....	....	*8.00*	*3.00*
A 3722	Wonder Guano	Wayne	F.†	0.49	0.08	0.17	0.74	10.90	2.18	8.72	2.97
A 3768	Wonder Guano	Adrian		0.57	0.12	0.12	0.81	10.20	2.18	8.02	3.24
A 3891	Wonder Guano	Nunica		0.53	0.14	0.14	0.81	10.65	2.14	8.51	**2.89**
A 4213	Wonder Guano	Quincy		0.48	0.16	0.16	0.80	10.45	2.52	7.93	2.95
A 4159*	Wonder Guano	Cass City		0.36	0.13	0.14	**0.63**	11.30	1.90	9.40	3.06
A 4593*	Wonder Guano	Quincy		0.52	0.17	0.17	0.86	10.05	1.06	8.99	3.01
A 4663*	Wonder Guano	Ottawa Lake		0.60	0.18	0.13	0.91	10.35	1.06	9.29	3.07
		Average		0.51	0.14	0.14	0.79	10.55	1.86	8.69	3.03
			G.†	....	....	....	....	....	....	*10.00*	*8.00*
A 4250	10–8 Phosphate and Potash	Tecumseh	F.†	....	....	....	....	12.20	1.04	11.16	8.96
			G.†	....	....	....	....	....	....	*10.00*	*10.00*
A 3883	10–10 Phosphate and Potash	Harlem	F.†	....	....	....	....	11.95	1.12	10.83	**8.29**
A 4066	10–10 Phosphate and Potash	Decatur		....	....	....	....	12.55	1.20	11.35	**8.54**
A 4252	10–10 Phosphate and Potash	Tecumseh		....	....	....	....	11.95	1.00	10.95	9.93
		Average		....	....	....	....	12.15	1.11	11.04	**8.92**

			G.†							*12.00*	*2.00*
A 3721	12-2 Phosphate and Potash	Wayne	F.†					14 75	1.84	12 91	**1.85**
A 3895	12-2 Phosphate and Potash	Conklin						13.75	2.19	**11.56**	2 02
A 4247	12-2 Phosphate and Potash	Tecumseh						14 60	1.60	13 00	**1.63**
A 4316	12-2 Phosphate and Potash	Reading						13.85	1.74	12.11	2.56
A 3992*	12-2 Phosphate and Potash	Coopersville						14 60	0.92	13 68	2.03
A 4131*	12-2 Phosphate and Potash	Charlotte						14.35	0 98	13.37	2 06
A 4559*	12-2 Phosphate and Potash	Washington						15 75	2.26	13 49	2.11
A 4580*	12-2 Phosphate and Potash	Eaton Rapids						14.25	2.16	12.09	**1 89**
		Average						14.49	1.71	12.78	2.02
			G.†							*12 00*	*4.00*
A 3723	12-4 Phosphate and Potash	Wayne	F.†					14.78	4.14	**10 64**	**3.44**
A 3767	12-4 Phosphate and Potash	Adrian						14.35	2.06	12 29	4.50
A 3931	12-4 Phosphate and Potash	Kent City						15.40	2.30	13.10	4.09
A 4212	12-4 Phosphate and Potash	Quincy						14 60	2.34	12 26	4.27
A 4378	12-4 Phosphate and Potash	Clayton						13.90	1.76	12 14	4.56
A 4419	12-4 Phosphate and Potash	Petersburg						13.68	3.64	**10 04**	**3.47**
A 4520*	12-4 Phosphate and Potash	Rochester						14 00	1.10	12.90	4.09
A 4558*	12-4 Phosphate and Potash	Washington						15.20	1 32	13.88	4 04
A 4648*	12-4 Phosphate and Potash	Hillsdale						13.80	1.24	12.56	**3.63**
		Average						14.41	2.21	12.20	4.01
			G.†				*1.60*			*8 00*	*15.00*
A 3841	2-8-15	Fennville	F.†	0.97	0 24	0 29	1.50	10 00	1.02	8.98	**14.26**
A 3850	2-8-15	Mentha		1 10	0 24	0 35	1.69	10 05	1.06	8.99	**14 24**
A 4060	2-8-15	Portage		1 18	0 20	0 19	1.57	10 15	1.10	9 05	**13 76**
A 4069	2-8-15	Decatur		1.17	0.26	0 22	1.65	10.40	1.10	9.30	**14 73**
A 4087	2-8-15	Three Oaks		1 34	0 15	0 24	1.73	10 35	1.04	9 31	**14 04**
A 4253	2-8-15	Tecumseh		1 25	0.16	0 19	1 60	10 25	1.00	9.25	**13.50**
		Average		1.17	0.21	0 24	1.62	10.20	1.05	9.15	**14.09**
	6-10 Phosphate and Potash		G.†							*6.00*	*10.00*
	Smith Agricultural Chem. Co., Columbus, Ohio										
			G.†							*16 00*	
A37 20	16% Acid Phosphate	Wayne	F.†					18.20	1 04	17.16	
A 3726	16% Acid Phosphate	Plymouth						18.70	1.42	17.28	
A 4041	16% Acid Phosphate	Nunica						18 05	0 90	17 15	
A 4124*	16% Acid Phosphate	Zeeland						17.95	0.80	17 15	
		Average						18.22	1.04	17.18	

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Smith Agricultural Chemical Co.—Cont.										
			G.†	....	....	....	*0.80*	....	....	*8.00*	*1.00*
A 4043	Ammoniated Phosphate & Potash	Nunica	F.†	0 48	0 15	0 10	0 73	9.90	0 92	8.98	**0.89**
A 4256	Ammoniated Phosphate & Potash	Cadmus		0 53	0 14	0 17	0.84	8.70	0.70	8 00	1.00
A 4323	Ammoniated Phosphate & Potash	Camden		0 60	0.10	0 10	0.80	11.05	0.92	10.13	1.05
A 4460	Ammoniated Phosphate & Potash	Waltz		0 54	0.15	0 25	0.94	9.70	1.10	8.60	0.99
A 4549*	Ammoniated Phosphate & Potash	Richmond		0 52	0 13	0 14	0.79	10.30	1.28	9 02	1.16
		Average		0 53	0.14	0.15	0 82	9.93	0.98	8.95	1.02
			G.†	....	....	....	....	....	....	*10.00*	*4.00*
A 3826	Climax Phosphate	Zeeland	F.†	....	....	....	....	10 65	0.42	10.23	**3.47**
A 4451	Climax Phosphate	Milan		....	....	....	....	11.10	0.58	10.52	4.17
		Average		....	....	....	....	10.87	0.50	10.37	**3.82**
			G.†	....	....	....	*1 60*	....	....	*10.00*	....
A 3963	Crop Producer	Cassopolis	F.†	1.27	0.18	0 11	1 56	10 40	0.80	**9 60**	....
A 4492	Crop Producer	Plymouth		1.26	0 22	0 07	1.55	11.40	0.88	10.52	....
		Average		1.26	0.20	0.09	1.55	10.90	0.84	10.06	....
			G.†	....	....	....	*0.80*	....	....	*15.00*	*1.00*
A 4381	Grain Grower	Palmyra	F.†	0 46	0.14	0.20	0.80	16.50	1.20	15.30	1.23
			G.†	....	....	....	*0 80*	....	....	*15.00*	*1.00*
A 4414	Grain Grower	Petersburg	F.†	0 64	0.12	0.17	0.93	16.45	1.44	15.01	1.20
			G.†	....	....	....	*0 80*	....	....	*10.00*	....
A 3962	Smith's One-Ten	Cassopolis	F†	0.58	0.13	0 09	0.80	12.05	0.86	11.19	....
			G.†	....	....	....	....	....	....	*10.00*	*2.00*
A 4042	Phosphate & Potash	Nunica	F.†	....	....	....	....	12.15	0.66	11.49	**1.49**
A 4255	Phosphate & Potash	Cadmus		....	....	....	....	10.85	0.52	10.33	**1.71**
A 4413	Phosphate & Potash	Petersburg		....	....	....	....	9.85	0.52	**9.33**	2.03
		Average		....	....	....	....	10.95	0.57	10.38	**1.74**

			G.†				0.82			8.00	2.00
A 3825	Potash Formula	Zeeland	F.†	0.38	0.16	0.25	0.79	10.30	0.64	9.66	1.68
A 4380	Potash Formula	Palmyra		0.48	0.11	0.14	0.73	10.10	0.60	9.50	1.87
A 4450	Potash Formula	Milan		0.25	0.03	0.10	0.38	9.20	0.62	8.58	1.98
A 4123*	Potash Formula	Zeeland		0.62	0.11	0.13	0.86	9.55	1.18	8.37	2.17
		Average		0.43	0.10	0.16	0.69	9.79	0.76	9.03	1.92
			G.†				0.40			12.00	
A 3719	Wheat Maker & Seeding Down	Wayne	F.†	0.17	0.12	0.16	0.45	14.35	1.06	13.29	
	Sodus Humus Company, Benton Harbor, Mich.										
			G.†				2.60	0.08			0.28
A 3912	Sodus Humus	Benton Harbor	F.†	0.13	0.46	1.21	1.80				
	Southern Fertilizer & Chem. Co., Savannah, Ga.										
			G.†							16.00	
A 4127*	16% Acid Phosphate	Vermontville	F.†					19.20	1.94	17.26	
A 4133*	16% Acid Phosphate	Charlotte						18.65	1.68	16.97	
A 4135*	16% Acid Phosphate	Bellevue						19.65	0.82	18.83	
A 4149*	16% Acid Phosphate	Lamb						18.80	2.00	16.80	
A 4563	16% Acid Phosphate	Holly						18.75	1.62	17.13	
A 4568*	16% Acid Phosphate	Grand Blanc						19.10	2.06	17.04	
A 4584*	16% Acid Phosphate	Eaton Rapids						18.35	1.12	17.23	
		Average						18.93	1.61	17.32	
			G.†							10.00	2.00
A 4140*	Southern Bone & Potash 0-10-2	Birch Run	F.†					11.40	1.20	10.20	2.03
A 4676*	Southern Bone & Potash 0-10-2	Durand						13.40	1.80	11.60	1.42
		Average						12.40	1.50	10.90	1.72
			G.†							10.00	4.00
A 4139*	Southern Bone & Potash 0-10-4	Birch Run	F.†					11.55	1.14	10.41	3.69
A 4173*	Southern Bone & Potash 0-10-4	Frankenmuth						12.60	2.04	10.56	3.36
		Average						12.07	1.59	10.48	3.53
			G.†							12.00	2.00
A 4148*	Southern Bone & Potash 0-12-2	Memphis	F.†					13.60	1.32	12.28	2.02
A 4628*	Southern Bone & Potash 0-12-2	Ypsilanti						13.33	1.96	11.37	1.83
A 4670*	Southern Bone & Potash 0-12-2	Bennington						13.58	1.81	11.77	2.00
		Average						13.50	1.69	11.81	1.95
			G.†				0.82			8.00	1.00
A 4164*	Southern Fertilizer 1-8-1	Bad Axe	F.†	0.58	0.19	0.06	0.83	9.60	1.22	8.38	1.02

†Abbreviation for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Southern Fertilizer & Chem. Co.—Cont.										
			G.†				*0.82*			*8.00*	*2.00*
A 4165*	Southern Fertilizer 1-8-2	Port Austin	F.†	0.49	0.24	0.08	0.81	10.40	1.00	9.40	2.06
A 4629*	Southern Fertilizer 1-8-2	Ypsilanti		0.55	0.19	0.12	0.86	10.20	1.42	8.78	2.06
		Average		0.52	0.22	0.10	0.84	10.30	1.21	9.09	2.03
			G.†				*1.65*			*12.00*	
A 4154*	2-12-0 Southern Fertilizer	Mayville	F.†	1.03	0.29	0.12	**1.44**	15.55	2.40	13.51	
A 4564*	2-12-0 Southern Fertilizer	Holly		0.98	0.31	0.08	**1.37**	14.30	1.90	12.40	
A 4611*	2-12-0 Southern Fertilizer	Macon		0.91	0.37	0.15	**1.43**	15.10	1.86	13.24	
A 4643*	2-12-0 Southern Fertilizer	Petersburg		0.89	0.36	0.08	**1.33**	14.20	2.16	12.04	
		Average		0.95	0.33	0.11	**1.39**	14.79	1.99	12.80	
			G.†				*1.65*			*12.00*	*2.00*
A 4153*	2-12-2 Southern Fertilizer	Mayville	F.†	1.18	0.25	0.13	1.56	13.80	1.62	12.18	**1.74**
A 4161*	2-12-2 Southern Fertilizer	Cass City		1.19	0.23	0.15	1.57	14.05	1.61	12.44	1.99
A 4598*	2-12-2 Southern Fertilizer	Burlington		1.04	0.25	0.17	**1.46**	14.05	1.64	12.41	2.10
A 4630*	2-12-2 Southern Fertilizer	Ypsilanti		0.96	0.28	0.04	**1.28**	14.20	2.14	12.06	2.20
A 4642*	2-12-2 Southern Fertilizer	Petersburg		1.04	0.38	0.06	**1.48**	13.80	0.66	13.14	2.03
		Average		1.08	0.28	0.11	**1.47**	13.98	1.53	12.45	2.01
	Southern Acid Phosphate 14%		G.†							*14.00*	
	Southern Bone & Potash 0-12-4		G.†							*12.00*	*4.00*
	Southern Fertilizer 1-8-3		G.†				*0.82*			*8.00*	*3.00*
	Southern Fertilizer 1-8-4		G.†				*0.82*			*18.00*	*4.00*
	Southern Fertilizer 1-10-0		G.†				*0.82*			*10.00*	
	Southern Fertilizer 1-10-2		G.†				*0.82*			*10.00*	*2.00*
	Southern Fertilizer 1-11-1		G.†				*0.82*			*11.00*	*1.00*
	Southern Fertilizer 1-12-2		G.†				*0.82*			*12.00*	*2.00*

	Southern Fertilizer 2-8-2		G.†				1 65			8.00	2.00
	Southern Fertilizer 2-10-0		G.†				1 65			10.00	
	Southern Fertilizer 2-10-2		G.†				1 65			10.00	2.00
	Southern Fish Fertilizer		G.†				1 65			12.00	3.00
	J. L. & H. Stadler Rend & Fert. Co., Cleveland, O.										
			G.†,							16.00	
A 4302	16% Acid Phosphate	Jasper	F.†					18 10	0 68	17.42	
A 4322	16% Acid Phosphate	Montgomery						18.00	0 34	17.66	
		Average						18 05	0.51	17.54	
			G.†							10.00	2.00
A 4221	Acid Phosphate and Potash	Quincy	F.†					13.75	1.04	12 71	**1.62**
A 4320	Acid Phosphate and Potash	Montgomery						10 95	0.74	10.21	1 95
A 4447	Acid Phosphate and Potash	Milan						11.85	0 50	11.35	2.03
A 4639*	Acid Phosphate and Potash	Maybee						1.05	0 50	10 55	**1.6**
		Average						11.90	0.69	11.21	**1.81**
			G.†				0 80			10.00	
A 4303	Ammoniated Acid Phosphate	Jasper	F.†	0 66	0 09	0 06	0 81	11.30	1.12	10.18	
A 4454	Ammoniated Acid Phosphate	Maybee		0 47	0 14	0 15	0.76	11.40	1.02	10.38	
		Average		0 56	0 12	0.11	0.79	11.35	1.07	10 28	
			G.†				0 80			8 00	3 00
A 4220	Corn and Wheat Special	Quincy	F.†	0 59	0 14	0 21	0 91	7.68	0 68	**7 00**	3 09
A 4321	Corn and Wheat Special	Montgomery		0 65	0 11	0 14	0 90	7 80	0 58	**7 22**	3 08
A 4591*	Corn and Wheat Special	Quincy		0 46	0 15	0 33	0 94	10 15	1 24	8 91	3 01
A 4637*	Corn and Wheat Special	Maybee		0 46	0 16	0 28	0 90	10 40	1.22	9.18	3 26
		Average		0 54	0 14	0 24	0 92	9 01	0 93	8.08	3.11
			G.†				0 82			9.00	1 00
A 3765	Harvest King	Blissfield	F.†	0 51	0 11	0 26	0 88	10 75	0 76	9 99	1 00
A 4219	Harvest King	Quincy		0 48	0 16	0 19	0 83	12 40	1 40	11.00	0 98
A 4590*	Harvest King	Quincy		0 47	0 19	0 37	1 03	11 75	1 24	10.51	1 01
		Average		0 49	0 15	0 27	0 91	11.63	1.13	10 50	1 00
			G.†							10 00	5.00
A 4218	Special Mixture	Quincy	F.†					11.80	1 18	10.62	4 97
A 4455	Special Mixture	Maybee						10.95	0 94	10 01	**4.48**
A 4638*	Special Mixture	Maybee						11 40	0 88	10.52	5 04
		Average						11 38	1 00	10.38	**4.83**

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at	Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	J. L. & H. Stadler Rend. & Fert. Co.—Cont.									
		G.†				*2.00*			*9.23*	*1.50*
A 4589*	Valley Phosphate	Quincy F.†	1.13	0.32	0.63	2.08	11.50	1.54	9.96	1.84
A 4631*	Valley Phosphate	Milan	1.05	0.32	0.62	1.99	12.70	2.76	9.94	1.57
		Average	1.09	0.32	0.62	2.03	12.10	2.15	9.95	**1.71**
	Bone and Acid Phosphate	G.†				*1.43*			*10.00*	
	Grain Grower	G.†				*1.60*			*8.00*	*2.00*
	Pure Bone Meal	G.†				*2.80*	*20.00*			
		G.†				*1.20*			*12.00*	
A 4636*	Vegetable Manure	Maybee F.†	0.95	0.27	0.49	1.71	14.00	1.44	12.56	
A 4669*	Vegetable Manure	Pitsford	0.59	0.27	0.32	1.18	15.00	0.82	14.18	
		Average	0.77	0.27	0.41	1.45	14.50	1.13	13.37	
	H. Stewart & Sons, Battle Creek, Mich.									
		G.†				*4.50*	*15.00*			
A 3923	Tankage	Battle Creek F.†	1.69	0.22	3.16	5.07	**13.85**			
	Swift & Company, Chicago, Ill.									
		G.†				*0.82*			*8.00*	*3.00*
A 3774	Bean & Grain Grower	Hillsdale F.†	0.47	0.11	0.33	0.91	11.50	1.36	10.14	**2.00**
A 3783	Bean & Grain Grower	Ypsilanti	0.39	0.14	0.35	0.88	9.80	1.42	8.38	**2.52**
A 4076	Bean & Grain Grower	Decatur	0.52	0.15	0.23	0.90	11.40	1.42	9.98	**2.44**
A 4236	Bean & Grain Grower	Manchester	0.59	0.14	0.21	0.94	10.10	1.76	8.34	3.55
A 4605*	Bean & Grain Grower	Manchester	0.61	0.10	0.10	0.81	9.80	1.10	7.80	3.18
A 4694*	Bean & Grain Grower	Cass City	0.46	0.18	0.24	0.88	9.50	1.06	8.44	3.19
		Average	0.51	0.14	0.24	0.89	10.20	1.35	8.35	**2.81**
		G.†				*1.65*			*12.00*	*2.00*
A 3792	Champion Wheat & Corn Grower	Albion F.†	1.41	0.10	0.12	1.63	14.05	0.72	13.33	**1.78**
A 3902	Champion Wheat & Corn Grower	Portage	1.49	0.17	0.10	1.76	13.75	0.86	12.89	2.08
A 4271	Champion Wheat & Corn Grower	Hudson	1.49	0.19	0.02	1.70	14.30	1.00	13.30	2.10
A 4313	Champion Wheat & Corn Grower	Reading	1.57	0.14	0.07	1.78	13.25	0.80	12.45	2.74
A 4112*	Champion Wheat & Corn Grower	Hamilton	1.30	0.21	0.20	1.71	13.80	1.40	12.76	2.00
A 4586*	Champion Wheat & Corn Grower	Quincy	0.79	0.13	0.11	**1.03**	13.28	1.50	**11.78**	**1.41**
		Average	1.34	0.16	0.10	1.60	13.74	0.99	12.75	2.02

			G.†				*1.65*			*12.00*	
A 4485	Clay Soil Special	Columbus	F.†	1.18	0.18	0.07	1.43	13.05	0.84	12.21	
A 4504	Clay Soil Special	Bad Axe		1.27	0.20	0.21	1.68	14.30	0.90	13.40	
A 4115*	Clay Soil Special	Kent City		1.30	0.21	0.10	1.61	14.75	0.86	13.89	
		Average		1.25	0.19	0.13	1.57	14.03	0.87	13.16	
			G.†				*0.82*			*12.00*	*1.00*
A 3775	Diamond K Grain Grower	Hillsdale	F.†	0.60	0.13	0.18	0.91	14.20	1.38	12.82	0.93
A 3833	Diamond K Grain Grower	Marne		0.52	0.22	0.17	0.91	14.40	1.50	12.90	0.95
A 3893	Diamond K. Grain Grower	Ravenna		0.59	0.19	0.08	0.86	13.35	1.38	11.97	1.21
A 4314	Diamond K. Grain Grower	Reading		0.78	0.19	0.02	0.09	14.00	1.04	12.96	1.32
A 3981	Diamond K Grain Grower	Marne		0.73	0.18	0.03	0.94	14.65	1.16	13.49	1.13
		Average		0.64	0.18	0.10	0.92	14.12	1.29	12.83	1.11
			G.†				*2.47*			*10.00*	*4.00*
A 3958	Fruit & Vegetable Grower	Fennville	F.†	1.53	0.13	0.07	1.73	7.83	0.74	7.09	6.99
A 4062	Fruit & Vegetable Grower	Portage		2.03	0.19	0.16	2.38	12.55	0.88	11.67	3.67
		Average		1.78	0.16	0.12	2.06	10.19	0.81	9.38	5.33
			G.†							*14.00*	
A 4163*	Garden City Acid Phosphate	Bad Axe	F.†					16.93	0.90	16.03	
			G.†				*1.65*			*10.00*	*4.00*
A 3955	Grain & Tobacco Grower	Fennville	F.†	1.21	0.14	0.11	1.46	11.60	1.26	10.34	3.65
A 3973	Grain & Tobacco Grower	Essexville		1.42	0.12	0.09	1.63	12.75	0.96	11.79	2.42
		Average		1.32	0.13	0.10	1.55	12.17	1.11	11.06	3.04
			G.†							*16.00*	
A 4088	High Grade Acid Phosphate	Three Oaks	F.†					18.35	1.44	16.91	
A 4238	High Grade Acid Phosphate	Manchester						18.90	0.95	17.95	
A 4272	High Grade Acid Phosphate	Hudson						19.00	0.82	18.18	
A 3982*	High Grade Acid Phosphate	Marne						19.05	1.31	17.71	
A 4578*	High Grade Acid Phosphate	Eaton Rapids						19.20	0.70	18.50	
		Average						18.90	1.05	17.85	
			G.†				*0.82*			*12.00*	*3.00*
A 3732	Muck Soil Fertilizer	Pontiac	F.†	0.68	0.14	0.15	0.97	14.85	1.80	13.05	2.72
A 4059	Muck Soil Fertilizer	Portage		0.66	0.12	0.08	0.86	13.95	1.26	12.69	3.33
A 4326	Muck Soil Fertilizer	North Adams		1.34	0.15	0.10	1.59	13.70	0.84	12.86	1.84
A 4351	Muck Soil Fertilizer	Flushing		0.55	0.15	0.16	0.86	13.55	1.32	12.23	3.20
A 4668*	Muck Soil Fertilizer	Adrian		0.61	0.16	0.11	0.88	14.40	1.88	12.52	3.18
		Average		0.77	0.14	0.12	1.03	14.09	1.42	12.67	2.86

†Abbreviations for guaranteed and found.
*Fall samples

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Swift & Co.—Cont.										
			G.†	....	....	....	*1.65*	....	....	*1.00*	*2.00*
A 3781	Pulverized Manure	Ypsilanti	F.†	0.24	0.37	1.27	1.88	1.05	0.22	0.83	2.31
A 4058	Pulverized Manure	Kalamazoo		0.25	0.34	1.12	1.71	1.50	0.58	0.92	1.90
		Average		0.25	0.35	1.19	1.179	1.27	0.40	0.87	2.1
	Special Truck Fertilizer	....	*G.*†	....	....	....	*2.47*	....	....	*10.00*	*2.00*
			G.†	....	....	....	*1.65*	....	....	*8.00*	*2.00*
A 3832	Superphosphate 2-8-2	Marne	F.†	1.20	0.18	0.26	1.64	9.65	0.90	8.75	2.19
A 4315	Superphosphate 2-8-2	Reading		1.11	0.13	0.15	1.39	9.85	0.96	8.89	2.97
A 3980*	Superphosphate 2-8-2	Marne		1.21	0.21	0.17	1.59	9.90	0.86	9.04	1.15
		Average		1.18	0.17	0.19	1.54	9.80	0.91	8.89	2.10
			G.†	....	....	....	*0.82*	....	....	*12.00*	....
A 3956	Tankage & Bone Phosphate	Fennville	F.†	0.44	0.18	0.12	0.74	13.80	1.02	12.78	....
A 4224	Tankage & Bone Phosphate	Coldwater		0.69	0.20	0.19	1.08	15.50	1.34	14.16	....
A 4344	Tankage & Bone Phosphate	Chesaning		0.53	0.15	0.26	0.94	13.10	1.10	12.00	....
A 4585*	Tankage & Bone Phosphate	Quincy		0.55	0.19	0.10	0.84	14.50	1.68	12.82	....
		Average		0.55	0.18	0.17	0.90	14.22	1.28	12.94	....
			G.†	....	....	....	*0.82*	....	....	*10.00*	....
A 3834	1-10-0 Fertilizer	Jamestown	F.†	0.49	0.18	0.28	0.95	12.20	1.20	11.00	....
			G.†	....	....	....	*1.85*	*29.00*	....	....	....
A 3917	2 1/4 29 Bone Meal Fertilizer	Hartford	F.†	0.59	0.94	0.31	1.84	30.20	....	....	....
A 3957	2 1/4 29 Bone Fertilizer	Fennville		0.46	1.10	0.57	2.13	29.23	....	....	....
A 4667	2 1/4 29 None Meal Fertilizer	Adrian		0.52	0.98	0.56	2.06	29.30	....	....	....
		Average		0.52	1.01	0.48	2.01	29.58	....	....	....
			G.†	....	....	....	....	....	....	*10.00*	*4.00*
A 4167*	10-4 Fertilizer	Helena	F.†	....	....	....	....	12.00	1.28	10.72	4.12
A 4635*	10-4 Fertilizer	Milan		....	....	....	....	11.95	1.50	10.45	4.08
		Average		....	....	....	....	11.97	1.39	10.58	4.10

			G.†	....	....	....	....	....	....	*10.00*	*10.00*
A 3904	10-10 Fertilizer	Portage	F.†	....	....	....	....	11.45	1.43	10.02	**8.89**
A 4061	10-10 Fertilizer	Portage		....	....	....	....	13.48	1.88	11.60	**8.15**
A 4075	10-10 Fertilizer	Decatur		....	....	....	....	13.25	1.64	11.61	10.38
		Average		....	....	....	....	12.72	1.65	11.07	**9 14**
			G.†	....	....	....	....	....	....	*12.00*	*2.00*
A 4478	12-2 Fertilizer	Dryden	F.†	....	....	....	....	14.35	1.00	13.35	1.99
A 4506	12-2 Fertilizer	Croswell		....	....	....	....	14 15	1.46	12 69	2.03
A 4518	12-2 Fertilizer	Davison		....	....	....	....	14.55	1.34	13.21	2 04
		Average		....	....	....	....	14.35	1.26	13.09	2.02
			G.†	....	....	....	....	....	....	*12 00*	*4.00*
A 3967	12-4 Fertilizer	Pompeii	F.†	....	....	....	....	14 70	2.06	12.64	**3 43**
A 4237	12-4 Fertilizer	Manchester		....	....	....	....	12 45	1.95	**10 50**	4 16
		Average		....	....	....	....	13 58	2 01	**11.57**	**3 79**
			G.†	....	....	....	*0 82*	....	....	*8 00*	*1.00*
A 3773	1-8-1 Complete Fertilizer	Hillsdale	F.†	0.43	0 12	0 15	**0 70**	11.90	1 10	10 80	**0 67**
A 3782	1-8-1 Complete Fertilizer	Ypsilanti		0 44	0 14	0 21	0 79	9 90	1 12	8 78	1 64
A 4089	1-8-1 Compete Fertilizer	Three Oaks		0.42	0.14	0 23	0 79	9 80	1 02	8 78	1 00
A 4499	1-8-1 Complete Fertilizer	Juniata		0.38	0 14	0 28	0 80	9 05	1 08	7.97	1 03
A 4114*	1-8-1 Complete Fertilizer	Kent City		0.53	0 09	0 18	0 80	9 55	0.96	8 59	1.55
		Average		0.44	0 13	0 21	0.78	10 04	1.06	8 98	1.18
	1-8-3 Fertilizer		G.†	....	....	....	*0.82*	....	....	*8.00*	*3.00*
			G.†	....	....	....	*0 82*	....	....	*8.00*	*5 00*
A 4500	1-8-5 Fertilizer	Vassar	F.†	0 52	0.15	0 24	0.91	10 05	1.02	9 03	**4 57**
			G.†	....	....	....	*0 82*	....	....	*8 00*	*6 00*
A 3780	1-8-6 Fertilizer	Ypsilanti	F.†	0 42	0 12	0 25	0 79	10 70	2 02	8 68	**5 78**
A 3831	1-8-6 Fertilizer	Marne		0 57	0 15	0 14	0 86	9 70	1 66	8 04	**4 12**
A 3903	1-8-6 Fertilizer	Portage		0 55	0 11	0 11	0 77	9 36	1 52	7 87	**5 53**
A 4077	1-8-6 Fertilizer	Decatur		0 34	0 14	0 25	0 73	9 60	1 58	8 02	**5 69**
		Average		0 47	0 13	0 19	0 79	9 84	1 69	8 15	**5 28**
			G.†	....	....	....	*1 65*	....	....	*8 00*	*15 00*
A 3840	2-8-15 Fertilizer	Kalamazoo	F.†	1.27	0 12	0 17	1 56	9 50	1 04	8 46	15 66
A 3851	2-8-15 Fertilizer	Mentha		1 23	0 09	0 30	1 62	9 70	1 10	8 60	**14 51**
A 4074	2-8-15 Fertilizer	Decatur		1 26	0 10	0 10	**1 46**	10 05	1.02	9 03	15 37
		Average		1 25	0 11	0 19	1.55	9 75	1.05	8.70	15.18
			G.†	....	....	....	*2 47*	....	....	*10 00*	*6 00*
A 3948	3-10-6 Fertilizer	Walkerville	F.†	1 88	0 18	0 11	**2.17**	11 80	0.90	10.90	6 09

†Abbreviations for guaranteed and found.
*Fall sample.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	Swift & Co.—Cont.										
			G.†				*3.29*			*8.00*	*8.00*
A 3972	4-8-8 Fertilizer	Essexville	F.†	2.55	0.17	0.12	2.84	9.65	1.30	8.35	8.96
	Tennesee Coal, Iron & Railroad Co., Birmingham, Ala.										
	Duplex Basic Phosphate		*G.*†							*14.00*	
	Virginia Carolina Chemical Co., Cincinnati, Ohio										
			G.†							*10.00*	*4.00*
A 4399	V-C Acid & Potash King	Erie	F.†					12.40	1.86	10.54	4.33
			G.†							*16.00*	
A 4040	V-C 16% Acid Phosphate	Nunica	F.†					18.00	0.60	17.40	
A 4402	V-C 16% Acid Phosphate	Erie						17.70	0.34	17.36	
A 3999*	V-C 16% Acid Phosphate	Grand Rapids						17.70	0.32	17.38	
A 4105*	V-C 16% Acid Phosphate	Jamestown						17.25	0.40	16.85	
A 4662*	V-C 16% Acid Phosphate	Erie						16.55	0.50	16.05	
		Average						17.44	0.43	17.01	
			G.†							*20.00*	
A 3704	V-C 20% Acid Phosphate	Adrian	F.†					22.42	1.20	21.22	
A 4003	V-C 20% Acid Phosphate	Sparta						22.70	1.66	21.04	
A 4215	V-C 20% Acid Phosphate	Quincy						23.40	1.56	21.84	
A 4231	V-C 20% Acid Phosphate	Ann Arbor						22.49	0.58	21.91	
A 3996*	V-C 20% Acid Phosphate	Coopersville						21.35	0.20	21.15	
A 4588*	V-C 20% Acid Phosphate	Quincy						20.75	0.26	20.49	
		Average						22.18	0.91	21.27	
			G.†				*2.46*			*10.00*	*4.00*
A 3935	V-C Big Potato & Truck	Fremont	F.†	1.98	0.20	0.32	2.50	10.90	0.78	10.12	4.24
			G.†				*0.82*			*10.00*	
A 3703	V-C Bone Meal & Phosphate	Adrian	F.†	0.29	0.36	0.36	1.01	24.35	13.32	11.03	
A 4306	V-C Bone Meal & Phosphate	Morenci		0.46	0.28	0.10	0.84	24.40	13.60	10.80	
A 4233	V-C Bone Meal & Phosphate	Manchester		0.29	0.40	0.33	1.02	23.70	12.55	11.15	
A 4608*	V-C Bone Meal & Phosphate	Manchester		0.32	0.42	0.34	1.08	23.15	12.55	10.60	
		Average		0.34	0.36	0.28	0.98	23.90	13.01	10.89	

			G.†				*0.82*			*8.00*	*2.00*
A 4235	V-C Champion Corn & Wheat Grower	Manchester	F.†	0.64	0.11	0.18	0.93	10.40	1.12	9.28	2.51
A 4265	V-C Champion Corn & Wheat Grower	Clayton		0.57	0.13	0.18	0.88	10.80	1.00	9.80	2.03
		Average		0.61	0.12	0.18	0.91	10.60	1.06	9.54	2.27
	V-C Complete Fertilizer		G.†				*1.65*			*8.00*	*2.00*
			G.†				*0.82*			*8.00*	*1.00*
A 4039	V-C Complete Manure	Nunica	F.†	0.26	0.30	0.35	0.91	17.65	7.00	10.65	1.20
A 4401	V-C Complete Manure	Erie		0.59	0.13	0.16	0.88	10.55	1.06	9.49	1.52
A 4264	V-C Complete Manure	Clayton		0.70	0.11	0.10	0.91	10.30	1.12	9.18	1.26
A 4234	V-C Complete Manure	Manchester		0.60	0.14	0.14	0.88	10.40	1.42	8.98	1.20
A 4607*	V-C Complete Manure	Manchester		0.72	0.12	0.20	1.04	10.95	1.42	9.53	1.38
A 4661*	V-C Complete Manure	Erie		0.53	0.22	0.15	0.90	10.50	0.72	9.78	1.23
		Average		0.57	0.17	0.18	0.92	11.72	2.12	9.60	1.29
			G.†				*0.82*			*8.00*	*3.00*
A 4304	V-C Farmers Friend	Morenci	F.†	0.72	0.11	0.11	0.94	9.40	0.80	8.60	2.00
A 4606*	V-C Farmers Friend	Manchester		0.54	0.16	0.16	0.86	10.20	0.66	9.54	3.05
		Average		0.63	0.13	0.14	0.90	9.80	0.73	9.07	2.53
			G.†							*10.00*	*8.00*
A 3892	V-C Monarch Acid & Potash Compound	Nunica	F.†					12.35	1.30	11.05	8.98
A 4216	V-C Monarch Acid & Potash Compound	Quincy						12.70	1.26	11.44	8.73
A 4456	V-C Monarch Acid & Potash Compound	Carleton						12.35	1.02	11.33	8.28
		Average						12.46	1.19	11.27	8.66
			G.†				*4.92*			*8.00*	*2.00*
A 4412	V-C Plant Food for Vegetables, Lawns & Flowers	Dundee	F.†	3.82	0.70	0.77	5.29	9.95	2.25	7.70	2.00
			G.†				*1.65*			*10.00*	*8.00*
A 4311	V-C Pride of the North	Reading	F.†	1.52	0.15	0.18	1.85	12.40	2.14	10.26	9.40
A 3998*	V-C Pride of the North	Grand Rapids		1.37	0.12	0.25	1.74	11.60	0.50	11.10	7.66
		Average		1.44	0.14	0.21	1.79	12.00	1.32	10.68	8.53
			G.†							*12.00*	*2.00*
A 4400	V-C Prolific Grain Grower	Erie	F.†					14.20	0.92	13.28	2.33
A 4458	V-C Prolific Grain Grower	Waltz						14.30	0.58	13.72	2.38
		Average						14.25	0.75	13.50	2.35
			G.†							*14.00*	
A 4453	V-C Red Cross 14%	Monroe	F.†					17.10	0.32	16.78	

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.			Phosphoric acid.			Potash.
			As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Virginia Carolina Chemical Co.—Cont.									
		G.†	....	....	....	*1.65*	....	....	*11.00*	
A 4660*	V-C Rescue Fertilizer	Erie F.†	1.31	0.25	0.35	1.91	13.25	0.52	12.73	....
	V-C Richmus Fertilizer	G.†	....	....	....	*0.41*	....	....	*12.00*	....
		G.†	....	....	....	*1.65*	....	....	*12.00*	*2.00*
A 3754	V-C Springfall Fertilizer	Blissfield F.†	1.10	0.22	0.28	1.60	14.95	1.34	13.61	2.21
A 4232	V-C Springfall Fertilizer	Ann Arbor	1.31	0.19	0.27	1.77	14.60	1.04	13.56	2.59
A 4305	V-C Springfall Fertilizer	Morenci	1.43	0.11	0.13	1.67	14.80	0.94	13.86	2.52
A 3995*	V-C Springfall Fertilizer	Coopersville	1.28	0.23	0.25	1.76	13.95	0.32	13.63	2.14
		Average	1.28	0.19	0.23	1.70	14.58	0.91	13.67	2.37
		G.†	....	....	....	*0.82*	....	....	*13.00*	....
A 3755	V-C Sure Grain Producer	Blissfield F.†	0.52	0.26	0.22	1.00	15.20	0.94	14.26	....
	The Welch Chemical Co., Columbus, Ohio									
		G.†	....	....	....	*0.82*	....	....	*11.00*	*3.00*
A 4291	No. 1 Independent Favorite	Williamston F.†	0.56	0.08	0.16	0.80	12.15	2.04	10.11	3.18
A 4336	No. 1 Independent Favorite	Bancroft	0.44	0.07	0.14	**0.65**	12.30	1.16	11.11	**2.30**
A 4342	No. 1 Independent Favorite	Henderson	0.34	0.10	0.24	**0.68**	12.05	1.34	**10.71**	**2.09**
A 4613	No. 1 Independent Favorite	Saline	0.48	0.11	0.31	0.90	13.10	2.18	10.92	3.38
		Average	0.46	0.09	0.21	0.76	12.40	1.68	10.72	**2.74**
		G.†	....	....	....	*0.82*	....	....	*8.00*	*1.00*
A 3797	No. 2 Independent Bone Meal & Phosphate Mixture	Litchfield F.†	0.35	0.16	0.29	0.80	15.60	7.33	8.27	1.25
A 4355	No. 2 Independent Bone Meal & Phosphate Mixture	Linden	0.57	0.20	0.30	1.07	16.60	6.25	10.35	1.45
A 4151*	No. 2 Independent Bone Meal & Phosphate Mixture	Marlette	0.59	0.12	0.23	0.94	19.40	11.30	8.10	1.37
A 4614*	No. 2 Independent Bone Meal & Phosphate Mixture	Saline	0.61	0.14	0.18	0.93	16.10	5.64	10.46	1.19
		Average	0.53	0.16	0.25	0.94	16.92	7.63	9.29	1.32
		G.†	....	....	....	*0.41*	....	....	*8.00*	*1.00*
A 4244	No. 3 Independent Corn, Wheat, Oats & Clover	Manchester F.†	0.26	0.08	0.10	0.44	8.30	0.74	**7.56**	**0.86**
A 4278	No. 3 Independent Corn, Wheat, Oats & Clover	Hudson	0.21	0.07	0.17	0.45	8.75	0.96	**7.79**	1.16
A 4293	No. 3 Independent Corn, Wheat, Oats & Clover	Williamston	0.24	0.07	0.15	0.46	7.40	0.74	**6.66**	1.05
A 4118*	No. 3 Independent Corn, Wheat, Oats & Clover	Elmdale	0.20	0.07	0.18	0.45	9.20	1.20	8.00	**0.79**
A 4523*	No. 3 Independent Corn, Wheat, Oats & Clover	Grand Ledge	0.31	0.08	0.13	0.52	8.65	0.60	8.50	**0.78**

A 4537*	No. 3 Independent Corn, Wheat, Oats & Clover	Warren		0.25	0.07	0.13	0.45	9.55	1.25	8.30	1.01
A 4553*	No. 3 Independent Corn, Wheat, Oats & Clover	Richmond		0.17	0.07	0.17	0.41	9.65	1.22	8.43	1.18
		Average		0.23	0.07	0.15	0.45	8.78	0.96	7.82	0.98
			G.†				*0.82*			*8.00*	*1.00*
A 3798	No. 4 Independent Grain Special	Litchfield	F.†	0.45	0.09	0.19	0.73	8.40	0.96	**7.44**	1.00
A 4356	No. 4 Independent Grain Special	Linden		0.43	0.12	0.19	0.74	8.75	1.14	**7.61**	1.30
A 4431	No. 4 Independent Grain Special	Saline		0.25	0.06	0.09	0.40	15.20	1.46	13.74	1.00
A 4651*	No. 4 Independent Grain Special	Litchfield		0.48	0.14	0.24	0.86	9.00	0.90	8.10	1.01
		Average		0.40	0.08	0.20	**0.68**	10.34	1.11	9.23	1.08
			G.†				*0.82*			*8.00*	*4.00*
A 4119*	No. 4 Independent Grain Special 1920	Elmdale	F.†	0.40	0.15	0.22	0.77	10.65	1.54	9.11	4.07
A 4532*	No. 4 Independent Grain Special 1920	Utica		0.53	0.10	0.21	0.84	9.40	1.40	8.00	**2.92**
A 4554*	No. 4 Independent Grain Special 1920	Richmond		0.64	0.07	0.10	0.81	9.90	1.14	8.76	4.05
A 4622*	No. 4 Independent Grain Special 1920	Saline		0.56	0.10	0.27	0.93	9.50	1.46	8.04	4.52
		Average		0.53	0.11	0.20	0.84	9.86	1.38	8.48	**3.89**
			G.†				*1.65*			*10.00*	*2.00*
A 4132*	No. 5 Independent Universal Crop	Charlotte	F.†	1.45	0.28	0.21	1.94	14.80	2.52	12.28	2.04
A 4609*	No. 5 Independent Universal Crop	Manchester		1.49	0.22	0.26	1.97	14.75	2.46	12.29	2.75
A 4616*	No. 5 Independent Universal Crop	Saline		1.21	0.16	0.26	1.63	13.35	1.56	11.79	2.06
		Average		1.38	0.22	0.24	1.84	14.30	2.18	12.12	2.28
			G.†				*1.60*			*12.00*	*2.00*
A 4525*	No. 6 Independent High Grade General Crop	Grand Ledge	F.†	1.06	0.20	0.25	1.51	15.00	1.96	13.04	2.40
A 4117*	No. 6 Independent High Grade General Crop	Elmdale		1.25	0.20	0.25	1.70	15.75	2.36	13.39	2.05
A 4528*	No. 6 Independent High Grade General Crop	Warren		0.86	0.21	0.32	**1.39**	14.90	1.76	13.14	2.08
A 4531*	No. 6 Independent High Grade General Crop	Utica		1.11	0.11	0.20	**1.45**	13.90	1.44	12.46	2.33
A 4621*	No. 6 Independent High Grade General Crop	Saline		1.18	0.16	0.22	1.56	14.15	1.36	12.79	2.18
		Average		1.09	0.18	0.25	1.52	14.74	1.78	12.96	2.14
			G.†				*0.82*			*8.00*	*2.00*
A 3877	No. 7 Independent Corn & Wheat Special	Elmdale	F.†	0.54	0.09	0.18	0.81	8.83	1.18	**7.65**	1.95
A 3796	No. 7 Independent Corn & Wheat Special	Litchfield		0.51	0.13	0.14	0.78	9.70	1.16	8.54	2.00
A 4243	No. 7 Independent Corn & Wheat Special	Manchester		0.42	0.08	0.17	**0.67**	10.10	1.50	8.60	2.04
A 4266	No. 7 Independent Corn & Wheat Special	Clayton		0.40	0.08	0.19	**0.67**	9.75	0.96	8.79	2.04
A 4116*	No. 7 Independent Corn & Wheat Special	Elmdale		0.69	0.12	0.17	0.98	9.03	1.22	7.81	2.02
A 4524*	No. 7 Independent Corn & Wheat Special	Grand Ledge		0.63	0.16	0.15	0.94	9.50	1.10	8.40	**1.63**
A 4555*	No. 7 Independent Corn & Wheat Special	Richmond		0.47	0.14	0.14	0.75	9.40	1.32	8.08	2.01
		Average		0.52	0.11	0.17	0.80	9.47	1.21	8.26	1.96
			G.†				*0.41*			*12.00*	
A 4433	No. 9 Independent Ammoniated Phosphate	Saline	F.†	0.23	0.08	0.14	0.45	13.43	1.89	**11.54**	
A 4624*	No. 9 Independent Ammoniated Phosphate	Saline		0.17	0.08	0.16	0.41	13.55	1.58	11.97	
		Average		0.20	0.08	0.15	0.43	13.49	1.73	**11.76**	

†Abbreviations for guaranteed and found.
*Fall samples.

ANALYSES OF COMMERCIAL FERTILIZER FOR 1920, EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at	Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	The Welch Chemical Co.—Cont.									
		G.†	....	....	....	....	....	....	*16.00*	....
A 4430	No. 11 Independent High Grade Phosphate	Saline F.†	....	....	....	....	18.20	1.06	17.14	....
A 4526*	No. 11 Independent High Grade Phosphate	Warren	....	....	....	....	17.65	0.70	16.95	....
A 4556*	No. 11 Independent High Grade Phosphate	Romeo	....	....	....	....	17.30	0.84	16.46	....
A 4617*	No. 11 Independent High Grade Phosphate	Saline	....	....	....	....	17.50	0.78	16.72	....
		Average	....	....	....	....	17.66	0.84	16.82	....
		G.†	....	....	....	*0.82*	....	....	*8.00*	*4.00*
A 3861	Independent Michigan Truck Special	Charlotte F.†	0.64	0.08	0.23	0.95	10.00	1.82	8.18	3.63
A 4294	Independent Michigan Truck Special	Williamston	0.40	0.09	0.19	**0.68**	9.95	1.20	8.75	3.30
A 4432	Independent Michigan Truck Special	Saline	0.34	0.12	0.25	**0.71**	9.55	1.72	7.83	3.43
A 4335	Independent Michigan Truck Special	Bancroft	0.57	0.09	0.18	0.84	8.85	1.70	**7.15**	4.11
		Average	0.49	0.09	0.21	0.79	9.59	1.61	7.98	**3.62**
		G.†	....	....	....	....	....	....	*10.00*	*8.00*
A 4693*	Independent Potash Compound	Birch Run F.†	....	....	....	....	12.70	2.20	10.50	8.00
		G.†	....	....	....	*0.82*	....	....	*8.00*	*2.00*
A 4292	Independent Sugar Beet Special	Williamston F.†	0.58	0.09	0.13	0.80	7.85	0.98	**6.87**	1.90
	Wing & Evans, Detroit, Mich.									
		G.†	....	....	....	....	....	....	....	*54.37*
A 3839	"U-S" Potash	Fennville F.†	....	....	....	....	....	....	....	55.40
A 3934	"U-S" Potash	Fremont	....	....	....	....	....	....	....	58.10
		Average	....	....	....	....	....	....	....	56.75
	Wuichet Fertilizer Co., Dayton, Ohio									
		G.†	....	....	....	*0.40*	....	....	*8.00*	*3.00*
A 3711	EE Gem Fertilizer	Washington F.†	0.20	0.06	0.15	0.41	11.05	1.12	9.93	**2.49**
A 3852	EE Gem Fertilizer	Sparta	0.21	0.08	0.12	0.41	8.80	0.76	8.04	2.99
A 3875	EE Gem Fertilizer	Woodland	0.38	0.06	0.11	0.55	9.50	1.18	8.32	**2.83**
A 4333	EE Gem Fertilizer	Ovid	0.28	0.07	0.10	0.45	9.20	1.10	8.10	3.10
A 4145*	EE Gem Fertilizer	Otisville	0.20	0.07	0.15	0.42	8.60	1.17	**7.43**	3.02
A 4570*	EE Gem Fertilizer	Durand	0.17	0.09	0.13	0.39	11.70	1.50	10.20	**2.08**
A 4575*	EE Gem Fertilizer	Morrice	0.19	0.06	0.14	0.39	10.55	1.20	9.35	**2.63**
		Average	0.23	0.07	0.13	0.43	9.92	1.15	8.77	**2.73**

			G.†				*0 40*			*11.00*	
A 3709	EE Ruby Fertilizer	Washington	F.†	0 43	0 09	0.13	0.65	13.25	1.40	11.85	
A 3873	EE Ruby Fertilizer	Woodland		0.15	0 14	0.13	0.42	10.73	1.06	**9.67**	
A 4334	EE Ruby Fertilizer	Ovid		0.24	0 16	0 08	0.48	11 63	1.27	**10.36**	
A 4143*	EE Ruby Fertilizer	Otisville		0.35	0.11	0 24	0.70	12.05	1.94	**10.11**	
A 4577*	EE Ruby Fertilizer	Perry		0.16	0.20	0 15	0.51	12.25	0.99	11.31	
		Average		0.26	0.14	0.15	0.55	11.99	1.33	**10.66**	
			G.†				*0 80*			*8.00*	*1.00*
A 3710	EE Spot Cash Fertilizer	Washington	F.†	0 20	0.04	0 14	**0 38**	9 00	1 06	7 94	1.12
A 3874	EE Spot Cash Fertilizer	Woodland		0.44	0 08	0 17	**0 69**	8.68	1.22	**7 46**	0.95
A 4332	EE Spot Cash Fertilizer	Ovid		0 64	0.11	0 16	0 91	9.28	1.88	**7.40**	1.48
A 4346	EE Spot Cash Fertilizer	Montrose		0.56	0.11	0 21	0 88	9.55	1.59	7.96	1.62
A 4144*	EE Spot Cash Fertilizer	Otisville		0 35	0 16	0 33	0 84	8 85	2.44	**6 41**	1.33
A 4571*	EE Spot Cash Fertilizer	Durand		0 31	0 19	0 26	0 76	9 30	1.94	**7 36**	1.02
A 4576*	EE Spot Cash Fertilizer	Perry		0.48	0 09	0.16	0 73	9 20	1.26	7.94	1.03
		Average		0.43	0.11	0 20	0 74	9 12	1.63	**7.49**	1.22
			G.†				*1 60*			*8 00*	*8.00*
A 3713	Onion & Truck Fertilizer	Washington	F.†	1 00	0 07	0 28	**1 35**	9.75	1.34	8.41	8.33
A 4340	Onion & Truck Fertilizer	Henderson		1 03	0.10	0.21	**1 34**	9.25	1.31	7.91	8.54
		Average		1.02	0 08	0 25	**1 35**	9.50	1.34	8 16	8.44
			G.†							*16 00*	
A 4503	16 Per Cent Phosphate	Bay Port	F.†					17.45	0 60	16 85	
	Witherbee, Sherman & Co., Worcester, Mass.										
	Grade A Barium-Phosphate		G.†					*28 00*			

†Abbreviations for guaranteed and found.
*Fall samples.

RESULTS OF INSPECTION, SPRING SEASON 1921

On July 1st, 1921, when the administration of the fertilizer law was transferred to the Department of Agriculture, 43 manufacturers and distributors had licensed 405 brands of fertilizer for sale in Michigan during the period ending April 30th, 1922. Nine new companies with 37 brands are included in the list. One of these, the Groves Fertilizer Company, Cincinnati, O., will make no shipments until the fall season.

During the spring shipping season the inspectors collected 609 samples which are classified as follows:

Complete fertilizers	319
Alkaline phosphates	115
Ammoniated phosphates	53
Acid phosphates	84
Bone meal	11
Pulverized manure	12
Ammonium sulfate	4
Nitrate of soda	2
Muriate of potash	4
Kainit	1
Special	4
	609

Alkaline phosphates are not so-called because they have an alkaline reaction nor because they will produce an alkaline reaction in the soil for they are, in fact, acid in reaction. This term has been used by the trade to distinguish this particular type of fertilizer which is a mixture of acid phosphate and some potash bearing material. Ammoniated phosphate is a term used to designate mixtures containing only nitrogen and phosphoric acid. They are usually prepared by acidulating some organic ammoniate such as leather waste, hair or wool waste and rock phosphate. The process is essentially the same as that followed in the production of acid phosphate. Ammoniated phosphate may also be prepared by dry mixing some available nitrogen bearing material with acid phosphate.

Eighty-nine of the licensed brands were not found on the markets and the manufacturers report that no shipments were made of 58 of these during the spring. Most of these should be found during the fall season. These missing brands are included in the tables which follow but the guaranteed analysis only is given.

DISCUSSION OF RESULTS.

Of the 609 samples analyzed, 158 (25.9%) were found to be below guarantee in one or more ingredients. Thirty-nine (6.4%) were below in nitrogen, 2 (0.3%) in total phosphoric acid, 45 (7.4%) in available phosphoric acid and 100 (16.4%) in potash. As in the case of last year, the greatest number of deficiencies were due to potash. There is some evidence to indicate that these deficiencies have been due to inefficient factory help but there is also much evidence to indicate, in some cases, a very lax system of factory control.

The results of the inspection pretty accurately reflect the carefulness of the manufacturer in preparing his products for the market and every user of commercial fertilizer should carefully study the fertilizer bulletin, in order to determine what companies are consistently fulfilling their obligations. While the results of a single season may not be a fair criterion, as something beyond the immediate control of the officers of a company may happen to lower the standard of their product, the performance of a company over a period of years is an accurate index of its integrity and well meaning. The object of the inspection is to protect the user of commercial fertilizers against fraud and unless the real consumers make use of the results, by studying the bulletins, the inspection is not fulfilling its greatest usefulness.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	American Agricultural Chemical Co. Detroit Mich.										
			G.†				*1.56*	*9.00*		*8.00*	*5.00*
A 4973	A High Grade Garden & Veg. Fertilizer	Shelby	F.†	1.26	0.29	0.29	1.84	10.85	1.22	9.63	5.39
			G.†				*1.65*	*13.00*		*12.00*	*3.00*
A 4974	All Grain Fertilizer	Shelby	F.†	1.42	0.19	0.10	1.71	15.00	1.40	13.60	3.08
A 5385	All Grain Fertilizer	Washington		1.32	0.22	0.16	1.70	11.10	1.40	12.70	3.03
		Average		1.37	0.21	0.13	1.71	14.55	1.40	13.15	3.06
			G.†				*1.65*	*13.00*		*12.00*	
A 5297	AmoPhos Fertilizer	Detroit	F.†	1.18	0.41	0.18	1.77	15.05	1.90	13.15	
			G.†				*0.82*	*10.00*		*9.00*	*1.00*
A 5295	Beet Fertilizer 1916	Detroit	F.†	0.57	0.13	0.25	0.95	10.00	0.78	9.22	1.08
			G.†				*1.65*	*9.00*		*8.00*	*2.00*
A 4712	Climax Complete Fertilizer	Eaton Rapids	F.†	1.25	0.28	0.25	1.78	10.30	0.98	9.32	2.33
A 4963	Climax Complete Fertilizer	Eaton Rapids		1.29	0.25	0.27	1.81	10.85	0.94	9.91	2.27
		Average		1.27	0.27	0.26	1.80	10.58	0.96	9.62	2.30
			G.†					*13.00*		*12.00*	*2.00*
A 5352	Crown Phosphate & Potash	Davison	F.†					14.45	1.24	13.21	2.10
A 5353	Crown Phosphate & Potash	Elba						14.35	1.32	13.03	2.00
A 5384	Crown Phosphate & Potash	Washington						14.05	1.04	13.01	2.00
		Average						14.28	1.20	13.08	2.03
			G.†					*11.00*		*10.00*	*2.00*
A 4995	Dissolved Bone Phos. & Potash	Tyre	F.†					11.80	0.88	10.92	2.05
A 5383	Dissolved Bone Phos. & Potash	Washington						12.20	0.92	11.28	2.04
		Average						12.00	0.90	11.10	2.05
			G.†					*11.00*		*10.00*	*10.00*
A 4715	Double 10 Fertilizer	Eaton Rapids	F.†					11.20	0.90	10.30	10.13
A 4929	Double 10 Fertilizer	Muskegon Heights						12.60	0.46	12.14	9.22

A 4801	Double 10 Fertilizer	Holland		....	....	....	....	11.60	0 70	10 90	9 12
A 5358	Double 10 Fertilizer	Attica		....	....	....	....	12.20	0.82	11.38	11.00
		Average		....	....	....	....	11.90	0.72	11.18	9 87
			G.†	....	....	....	*0.82*	*9.00*	....	*8.00*	*2.00*
A 5259	Favorite Potash Fertilizer	Erie	F.†	0 52	0.15	0.24	0 91	9.75	0.70	9 05	2.93
A 5337	Favorite Potash Fertilizer	New Lothrop		0 66	0.14	0 25	1.05	9 90	0.42	9.48	2.02
		Average		0.59	0.14	0.25	0.98	9.83	0.56	9.27	2.48
			G.†	....	....	....	*1.65*	*27.00*	....	....	....
A 4874	Fine Ground Bone	Hartford	F.†	0 60	0.88	0.45	1.93	28.60	....	....	....
			G.†	....	....	....	....	*11.00*	....	*10.00*	*5.00*
A 4718	High Grade Phosphate & Potash	Hillsdale	F.†	....	....	....	....	11.75	1.70	10.05	**4 75**
			G.†	....	....	....	*1.65*	*9.00*	....	*8.00*	*10 00*
A 4189	Maine Potato Formula	Coopersville	F.†	1.15	0 30	0 25	1 70	9.55	1.14	8.41	12.07
			G.†	....	....	....	*0.82*	*9.00*	....	*8.00*	*3.00*
A 4717	M. & I. 3% Potash Fertilizer	Hillsdale	F.†	0 38	0.18	0 30	0 86	9.55	0 82	8.73	3.41
			G.†	....	....	....	*1 65*	*9.00*	....	*8.00*	*1.00*
A 5303	Michigan Bean Grower 1916	Detroit	F.†	1.23	0 28	0.27	1.78	9.75	1.24	8.51	1.26
			G.†	....	....	....	*0 82*	*6.00*	....	*5.00*	*10.00*
A 4191	Michigan 10% Potash Fertilizer	Coopersville	F.†	0 68	0 15	0 10	0 93	6.25	0 46	5.79	11.96
A 5204	Michigan 10% Potash Fertilizer	Wayne		1.26	0 28	0.23	1.77	9 90	1.00	8.90	10.06
		Average		0 97	0.21	0 17	1.35	8 08	0.73	7.35	11.01
			G.†	....	....	....	....	....	....	....	*48.00*
A 4806	Muriate of Potash	Holland	F.†	....	....	....	....	....	....	....	51.32
			G.†	....	....	....	*0.82*	*9 00*	....	*8.00*	*1.00*
A 4996	New York State Special 1916	Tyre	F.†	0 59	0 20	0 28	1 07	10.15	0.72	9 43	1.16
A 5257	New York State Special 1916	Erie		0 67	0 12	0 22	1.01	9 95	0.66	9 29	1.09
		Average		0 63	0 16	0 25	1 04	10.05	0 69	9.36	1.13
			G.†	....	....	....	*15 00*	....	....	....	....
A 4847	Nitrate of Soda	Fennville	F.†	....	....	....	16.02	....	....	....	....
			G.†	....	....	....	*0.82*	*11.00*	....	*10.00*	....
A 4997	1 and 10 Compound	Tyre	F.†	0 59	0 24	0 25	1 08	12.35	1 06	11.29	....
A 5370	1 and 10 Compound	Capac		0 74	0 28	0 27	1.29	13.65	1.44	12 21	....
		Average		0 67	0 26	0 26	1.19	13 00	1 25	11.75	....

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	American Agricultural Chem. Co.—Cont.										
			G.†	....	....	....	*1.65*	*11.00*	....	*10.00*	....
A 5326	Special Nitrophos	Detroit	F.†	1.09	0.43	0.31	1.83	12.85	1.76	11.09	....
			G.†	....	....	....	*20.16*	....	....	....	....
A 5306	Sulphate of Ammonia	Detroit	F.†	....	....	....	20.48	....	....	....	....
	Bradley Brands										
	Alkaline Phosphate & Potash	....	G.†	....	....	....	....	....	....	*10.00*	*2.00*
			G.†	....	....	....	*0.82*	*11.00*	....	*10.00*	*1.00*
A 5296	All Crops Fertilizer	Detroit	F.†	0.51	0.11	0.25	0.90	11.70	0.82	10.88	1.08
			G.†	....	....	....	*1.65*	*11.00*	....	*10.00*	....
A 4891	Bin Filler	Buchanan	F.†	1.10	0.41	0.26	1.77	12.35	1.96	10.39	....
			G.†	....	....	....	*1.65*	*9.00*	....	*8.00*	*1.00*
A 5314	B. D. Sea Fowl Guano with Potash	Detroit	F.†	1.25	0.31	0.17	1.73	9.80	1.12	8.68	1.26
			G.†	....	....	....	*0.82*	*9.00*	....	*8.00*	*1.00*
A 4892	Dissolved Bone Phos. with Potash 1916	Buchanan	F.†	0.55	0.19	0.27	1.01	9.45	0.64	8.81	1.20
			G.†	....	....	....	....	*17.00*	....	*16.00*	....
A 4890	16% Acid Phosphate	Buchanan	F.†	....	....	....	....	18.00	1.50	16.50	....
			G.†	....	....	....	....	*15.00*	....	*14.00*	....
A 5331	Soluble Dissolved Bone Phosphate	Detroit	F.†	....	....	....	....	15.85	1.46	14.39	....
	Crocker Brands										
			G.†	....	....	....	*1.65*	*9.00*	....	*8.00*	*1.00*
A 5315	Ammoniated Wheat & Corn Phos. 1916	Detroit	F.†	1.30	0.31	0.20	1.81	9.80	1.20	8.60	1.26
			G.†	....	....	....	*1.65*	*9.00*	....	*8.00*	*1.00*
A 4713	Bean Grower	Eaton Rapids	F.†	1.11	0.33	0.23	1.67	9.70	1.06	8.64	1.16
A 4964	Bean Grower	Eaton Rapids		1.17	0.35	0.24	1.76	10.70	0.98	9.72	1.11
		Average		1.14	0.34	0.24	1.72	10.20	1.02	9.18	1.14

A 5328	Complete Fertilizer	Detroit	G.†				0.82	11.00		10.00	1.00
			F.†	0.50	0.15	0.26	0.91	11.80	0.78	11.02	1.12
A 5330	Dissolved Bone Phosphate	Detroit	G.†					15.00		14.00	
			F.†					16.00	1.50	14.50	
73 A 4716	High Grade Phosphate	Eaton Rapids	G.†					17.00		16.00	
			F.†					18.55	1.66	16.89	
A 5396	High Grade Phosphate	Mason						18.40	1.26	17.14	
		Average						18.48	1.46	17.02	
A 4714	New Rival Ammoniated Superphosphate 1916	Eaton Rapids	G.†				0.82	10.00		9.00	1.00
			F.†	0.48	0.19	0.27	0.94	9.60	0.66	9.84	1.16
A 4965	New Rival Ammoniated Superphosphate 1916	Eaton Rapids		0.55	0.18	0.26	0.99	10.35	0.60	9.75	1.11
A 5354	New Rival Ammoniated Superphosphate 1916	Elba		0.64	0.14	0.23	1.01	9.70	0.18	9.22	1.29
		Average		0.56	0.17	0.25	0.98	9.88	0.58	9.30	1.91
A 5312	Sugar Beet Fertilizer	Detroit	G.†				0.82	10.00		9.00	1.00
			F.†	0.56	0.14	0.21	0.94	9.90	0.84	9.06	1.16
	Michigan Carbon Works Brands										
A 4744	A-1 Potash Fertilizer	St. Johns	G.†				0.82	9.00		8.00	3.00
			F.†	0.46	0.16	0.25	0.87	9.70	0.78	8.92	3.08
A 4977	A-1 Potash Fertilizer	Ithaca		0.60	0.14	0.24	0.98	10.05	0.78	9.27	3.17
A 5205	A-1 Potash Fertilizer	Wayne		0.63	0.14	0.30	1.07	9.65	0.51	9.11	2.95
		Average		0.56	0.15	0.26	0.97	9.80	0.70	9.10	3.07
A 4978	A-1 Potash Fertilizer 1916	Ithaca	G.†				0.82	9.00		8.00	1.00
			F.†	0.61	0.17	0.24	1.02	10.00	0.90	9.10	1.13
A 5290	A-1 Potash Fertilizer 1916	Grand Blanc		0.70	0.16	0.23	1.09	10.00	0.46	9.54	1.13
A 4382	A-1 Potash Fertilizer 1916	Detroit		0.54	0.17	0.28	0.99	9.90	0.90	9.00	1.09
		Average		0.62	0.16	0.25	1.03	9.97	0.75	9.22	1.12
A 4747	High Potash Phosphate	Ovid	G.†					11.00		10.00	5.00
			F.†					11.65	1.52	10.13	5.63
A 4832	High Potash Phosphate	Byron Center						12.15	1.80	10.35	5.01
A 5264	High Potash Phosphate	Maybee						11.70	1.54	10.16	4.90
		Average						11.83	1.62	10.21	5.18

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	American Agricultural Chem. Co.—Cont.										
	Michigan Carbon Works Brand—Cont.										
			G.†				*0.82*	*11.00*		*10.00*	
A 5298	New Standard Fertilizer	Detroit	F.†	0 56	0 22	0 21	1 02	12 00	0.96	11 04	
			G.†				*1 65*	*9 00*		*8 00*	*2.00*
A 5332	Red Line Crop Clover	Detroit	F.†	1 25	0 29	0.17	1.71	9 60	1.22	8.38	2 10
			G.†					*15.00*		*14 00*	
A 4190	Red Line Phosphate	Coopersville	F.†					16 40	1 78	14 62	
A 5203	Red Line Phosphate	Wayne						15 45	1 30	14 15	
		Average						15.93	1.54	14.39	
			G.†					*11 00*		*10.00*	*2 00*
A 4749	Red Line Phosphate with Potash	Ovid	F.†					11 70	1 08	10 62	2 00
A 5209	Red Line Phosphate with Potash	Milan						11 80	0 78	11 02	2 01
		Average						11.75	0 93	10 82	2 01
			G.†				*1 65*	*11 00*		*10 00*	
A 5323	Soil Builder	Detroit	F.†	1 26	0 41	0 25	1.92	12.75	1.68	11.07	
			G.†					*17 00*		*16.00*	
A 4192	Superior Acid Phosphate	Jamestown	F.†					18 30	1 88	16 42	
A 4707	Superior Acid Phosphate	Homer						17.70	1 50	16.20	
A 4748	Superior Acid Phosphate	Ovid						18 80	1 52	17 38	
A 4865	Superior Acid Phosphate	South Haven						18 10	1 30	16.80	
		Average						18 25	1.55	16.70	
			G.†				*1 65*	*13.00*		*12 00*	
A 4709	Triaton Fertilizer	Homer	F.†	1 14	0 38	0 15	1 67	14 50	21.6	12 24	
			G.†					*13 00*		*12 00*	*2 00*
A 5459	Usemore Fertilizer	Saline	F.†					11 20	1.22	12.98	2.10
	Michigan Carbon Works—Homestead										
			G.†				*1 65*	*9 00*		*8 00*	*1.00*
A 5316	Bean Fertilizer	Detroit	F.†	1.36	0.30	0.18	1.84	10 45	1.24	9 21	1.26

	Michigan Carbon Works—Homestead—Cont.										
			G.†	......	......	......	*0.82*	*11.00*	......	*10.00*	*1.00*
A 4708	Bialode Fertilizer	Homer	F.†	0.50	0.14	0.23	0.87	11.65	0.86	10.79	1.24
			G.†	......	......	......	*1.65*	*9.00*	......	*8.00*	*1.00*
A 4710	Bone Black Fertilizer with Potash	Homer	F.†	1.23	0.32	0.26	1.81	10.10	1.10	9.00	1.21
			G.†	......	......	......	*0.82*	*10.00*	......	*9.00*	*1.00*
A 4987	Bone Black Sugar Beet Fertilizer	Bay City	F.†	0.67	0.13	0.25	1.05	9.55	0.78	8.77	1.23
			G.†	......	......	......	*1.65*	*13.00*	......	*12.00*	*3.00*
A 4833	Grain Fertilizer	Byron Center	F.†	1.25	0.19	0.06	1.50	13.85	1.48	12.37	3.30
A 5387	Grain Fertilizer	Goodrich		1.39	0.18	0.09	1.66	14.65	1.40	13.25	2.72
		Average		1.32	0.19	0.07	1.58	14.25	1.44	12.81	3.01
			G.†	......	......	......	*1.65*	*9.00*	......	*8.00*	*5.00*
A 4799	High Grade Garden & Vegetable Fert.	Denton	F.†	1.25	0.29	0.30	1.84	10.60	1.26	9.34	5.25
A 5232	High Grade Garden & Vegetable Fert.	Riga		1.18	0.28	0.30	1.76	10.40	1.18	9.22	5.46
		Average		1.21	0.29	0.30	1.80	10.50	1.22	9.28	5.36
			G.†	......	......	......	*0.82*	*9.00*	......	*8.00*	*2.00*
A 4800	Special Potash Fertilizer	Denton	F.†	0.70	0.12	0.23	1.05	9.65	0.60	9.05	2.04
A 5422	Special Potash Fertilizer	Berville		0.62	0.12	0.19	0.93	10.50	0.76	9.74	2.04
		Average		0.66	0.12	0.21	0.99	10.08	0.68	9.40	2.04
			G.†	......	......	......	*0.82*	*10.00*	......	*9.00*	*1.00*
A 5311	Sugar Beet Fertilizer 1916	Detroit	F.†	0.73	0.13	0.22	1.08	10.25	0.82	9.43	1.12
	Niagara Brands										
			G.†	......	......	......	*1.65*	*9.00*	......	*8.00*	*1.00*
A 5317	Bean Grower	Detroit	F.†	1.33	0.30	0.18	1.81	10.15	1.34	8.81	1.38
			G.†	......	......	......	......	*15.00*	......	*14.00*	......
A 5338	Dissolved Bone Phosphate	New Lothrop	F.†	......	......	......	......	19.30	1.38	15.92	......
			G.†	......	......	......	*0.82*	*11.00*	......	*10.00*	*1.00*
A 4719	General Crop Fertilizer	Hillsdale	F.†	0.45	0.13	0.26	0.84	11.55	0.80	10.75	1.14
			G.†	......	......	......	......	*17.00*	......	*16.00*	......
A 5371	High Grade Phosphate	Capac	F.†	......	......	......	......	18.50	1.40	17.10	......

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	American Agricultural Chem. Co.—Cont.										
	Niagara Brands.—Cont.										
			G.†	....	....	....	*0.82*	*10.00*	....	*9.00*	*1.00*
A 5258	Wheat & Corn Producer 1916	Erie	F.†	0.62	0.11	0.24	0.97	10.15	0.66	9.49	1.01
	North Western Horse Shoe Brands										
			G.†	....	....	....	*0.82*	*11.00*	....	*10.00*	*1.00*
A 5201	Acidulated Bone Phosphate & Potash	Wayne	F.†	0.40	0.15	0.31	0.86	11.55	0.62	10.93	1.24
A 5405	Acidulated Bone Phosphate & Potash	Warren		0.39	0.15	0.30	0.84	12.10	0.82	11.28	1.22
		Average		0.39	0.15	0.31	0.85	11.83	0.72	11.11	1.23
			G.†	....	....	....	*1.65*	*9.00*	....	*8.00*	*1.00*
A 5319	Bean Special 1916	Detroit	F.†	1.38	0.31	0.18	1.87	9.80	1.28	8.52	1.32
			G.†	....	....	....	....	*11.00*	....	*10.00*	*2.00*
A 4767	Bone Phosphate & Potash	Swartz Creek	F.†	....	....	....	....	11.40	0.88	10.52	2.06
A 5403	Bone Phosphate & Potash	Warren		....	....	....	....	12.00	1.02	10.98	2.33
		Average		....	....	....	....	11.70	0.95	10.75	2.20
			G.†	....	....	....	*1.65*	*9.00*	....	*8.00*	*2.00*
A 4725	Corn and Wheat Grower	Adrian	F.†	1.20	0.26	0.27	1.73	9.80	1.00	8.80	2.67
A 4927	Corn and Wheat Grower	Muskegon Heights		1.07	0.29	0.27	1.63	10.15	0.88	9.27	2.84
A 5251	Corn and Wheat Grower	Plymouth		1.24	0.26	0.27	1.77	9.90	0.90	9.00	2.32
		Average		1.17	0.27	0.27	1.71	9.95	0.93	9.02	2.61
			G.†	....	....	....	*1.65*	*13.00*	....	*12.00*	....
A 5348	Dissolved Ammoniated Bone Phosphate	Davison	F.†	1.22	0.41	0.22	1.85	16.65	2.48	14.17	....
			G.†	....	....	....	*0.82*	*11.00*	....	*10.00*	....
A 4765	F. & F. Fertilizer	Swartz Creek	F.†	0.59	0.21	0.18	0.98	12.15	1.02	11.13	....
			G.†	....	....	....	*1.65*	*9.00*	....	*8.00*	*1.00*
A 4958	Garden City Superphosphate with Potash	Nashville	F.†	1.22	0.30	0.35	1.87	10.70	0.96	9.74	1.16
A 5226	Garden City Superphosphate with Potash	Blissfield		1.17	0.34	0.32	1.83	10.10	1.16	8.94	1.10
		Average		1.20	0.32	0.33	1.85	10.40	1.06	9.34	1.13

A 5336	High Grade Vegetable Fertilizer	Corunna	G.†				*1.65*	*9.00*		*8.00*	*5.00*
			F.†	1.21	0.27	0.26	1.74	11.20	1.02	10.18	5.14
			G.†					*11.00*		*10.00*	*5.00*
A 4764	0-10-5 Potash Manure	Swartz Creek	F.†					12.45	1.64	10.81	4.52
A 4928	0-10-5 Potash Manure	Muskegon Heights						12.30	1.34	10.98	4.92
		Average						12.38	1.49	10.89	4.72
	Potash Manure		G.†				*0.82*			*8.00*	*3.00*
			G.†				*0.82*	*9.00*		*8.00*	*1.00*
A 4727	Potash Manure 1916	Adrian	F.†	0.56	0.15	0.23	0.94	9.80	0.56	9.24	1.22
A 4766	Potash Manure 1916	Swartz Creek		0.55	0.17	0.22	0.94	9.45	0.86	8.59	1.06
		Average		0.56	0.16	0.22	0.94	9.63	0.71	8.92	1.14
			G.†					*17.00*		*16.00*	
A 4726	16% Phosphate	Adrian	F.†					17.85	1.42	16.43	
A 4873	16% Phosphate	Hartford						17.30	1.24	16.06	
A 4961	16% Phosphate	Nashville						19.10	1.40	17.70	
A 5420	16% Phosphate	Memphis						18.60	1.50	17.10	
		Average						18.21	1.39	16.82	
			G.†				*1.65*	*11.00*		*10.00*	
A 4960	Special Dissolved Amophos	Nashville	F.†	1.23	0.40	0.22	1.85	13.60	1.96	11.64	
			G.†				*1.65*	*13.00*		*12.00*	*3.00*
A 5247	Special Grain Fertilizer	Plymouth	F.†	1.32	0.18	0.10	1.60	13.85	1.42	12.43	3.01
A 5404	Special Grain Fertilizer	Warren		1.19	0.21	0.20	1.60	13.90	1.32	12.58	3.08
		Average		1.25	0.20	0.15	1.60	13.88	1.37	12.51	3.05
			G.†					*15.00*		*14.00*	
A 4724	Square Deal Phosphate	Adrian	F.†					15.95	1.36	14.59	
A 5412	Square Deal Phosphate	Memphis						17.20	1.42	15.78	
		Average						16.58	1.39	15.19	
			G.†				*0.82*	*10.00*		*9.00*	*1.00*
A 5307	Sugar Beet Fertilizer 1916	Linden	F.†	0.59	0.17	0.25	1.01	9.80	0.46	9.34	1.13
A 5335	Sugar Beet Fertilizer 1916	Corunna		0.62	0.11	0.24	0.97	10.15	0.50	9.65	1.06
		Average		0.60	0.14	0.25	0.99	9.98	0.48	9.50	1.10

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	American Agricultural Chemical Co.—Cont.										
	North Western Horse Shoe Brands—Cont.										
			G.†	......	......	......	*0.82*	*9.00*	......	*8.00*	*2.00*
A 4959	2 Potash Fertilizer	Nashville	F.†	0.60	0.13	0.26	0.99	10.30	0.60	9.70	2.01
A 5202	2 Potash Fertilizer	Wayne		0.67	0.14	0.20	1.01	9.60	0.66	8.94	2.20
A 5249	2 Potash Fertilizer	Plymouth		0.66	0.10	0.22	0.98	9.45	0.44	9.01	2.10
		Average		0.64	0.12	0.23	0.99	9.45	0.57	8.88	2.10
			G.†	......	......	......	......	*13.00*	......	*12.00*	*2.00*
A 5248	XXX Fertilizer	Plymouth	F.†	......	......	......	......	12.90	1.06	11.84	2.00
	Packers Boars Head Brands										
			G.†	......	......	......	*0.82*	*11.00*	......	*10.00*	*1.00*
A 5327	Ammoniated Bone Phosphate & Potash	Detroit	F.†	0.56	0.14	0.25	0.95	11.95	0.84	11.11	1.20
			G.†	......	......	......	*1.65*	*13.00*	......	*12.00*	*3.00*
A 4804	Best Grain Fertilizer	Holland	F.†	1.33	0.18	0.13	1.64	13.75	1.28	12.47	3.14
			G.†	......	......	......	*1.65*	*9.00*	......	*8.00*	*2.00*
A 5301	Corn and Wheat Grower	Detroit	F.†	1.20	0.30	0.26	1.76	9.75	1.26	8.49	2.22
			G.†	......	......	......	......	*11.00*	......	*10.00*	*2.00*
A 5406	Dissolved Phosphate & Potash	Warren	F.†	......	......	......	......	11.95	0.96	10.99	2.00
			G.†	......	......	......	......	*15.00*	......	*14.00*	......
A 5293	Gilt Edge Phosphate	Detroit	F.†	......	......	......	......	1.54	14.11	......	......
			G.†	......	......	......	*1.65*	*9.00*	......	*8.00*	*5.00*
A 5308	High Grade Vegetable Fertilizer	Detroit	F.†	1.18	0.30	0.30	1.78	10.10	1.14	8.96	5.46
			G.†	......	......	......	*0.82*	*11.00*	......	*10.00*	......
A 5323	New Compound	Detroit	F.†	0.53	0.23	0.25	1.01	12.20	1.00	11.20	......
			G.†	......	......	......	*0.82*	*9.00*	......	*8.00*	*2.00*
A 4283	New Compound & Potash Fertilizer	Bancroft	F.†	0.51	0.15	0.22	0.88	10.00	0.82	9.18	2.33

			G.†	....	....	....	....	*13.00*	....	*12.00*	*2.00*
A 4802	Phospotash Fertilizer	Holland	F.†	....	....	....	....	13.15	1.22	11.93	2.09
			G.†	....	....	....	....	*11.00*	....	*10.00*	*5.00*
A 5357	Potash Phosphate Fertilizer	Attica	F.†	....	....	....	....	13.55	1.54	12.01	5.60
			G.†	....	....	....	....	*17.00*	....	*16.00*	....
A 5285	16% Phosphate	Bancroft	F.†	....	....	....	....	18.70	1.40	17.30	....
			G.†	....	....	....	*1.65*	*13.00*	....	*12.00*	....
A 4803	Success Fertilizer	Holland	F.†	1.18	0.39	0.17	1.74	15.10	2.22	12.88	....
			G.†	....	....	....	*0.82*	*10.00*	....	*9.00*	*1.00*
A 5034	Sugar Beet Grower 1916	North Star	F.†	0.67	0.14	0.23	1.01	10.00	0.86	9.14	1.00
A 5310	Sugar Beet Grower 1916	Detroit		0.70	0.13	0.18	1.01	10.00	0.82	9.18	1.12
		Average		0.68	0.14	0.21	1.03	10.00	0.84	9.16	1.06
			G.†	....	....	....	*0.82*	*9.00*	....	*8.00*	*3.00*
A 5284	Sure Growth Potash Manure	Bancroft	F.†	0.45	0.18	0.30	0.93	9.90	0.68	9.22	3.24
			G.†	....	....	....	*0.82*	*9.00*	....	*8.00*	*1.00*
A 4805	Sure Growth Potash Manure 1916	Holland	F.†	0.55	0.17	0.21	0.96	9.50	0.92	8.58	1.22
A 5381	Sure Growth Potash Manure 1916	Romeo		0.60	0.12	0.23	0.95	9.60	0.54	9.06	1.13
		Average		0.57	0.15	0.24	0.96	9.55	0.73	8.82	1.18
			G.†	....	....	....	*1.65*	*11.00*	....	*11.00*	....
A 5324	2 and 10 Compound	Detroit	F.†	1.25	0.41	0.26	1.92	12.70	1.28	10.92	....
			G.†	....	....	....	*1.65*	*9.00*	....	*8.00*	*1.00*
A 5318	World of Good Superphosphate with Potash	Detroit	F.†	1.36	0.31	0.21	1.88	10.00	1.34	8.66	1.36
	Michigan State Grange Brands										
	All Crops Special Fertilizer	....	G.†	....	....	....	*0.82*	....	....	*8.00*	*1.00*
	Ammoniated Bone and Potash	....	G.†	....	....	....	*0.82*	....	....	*10.00*	*1.00*
	Corn and Oats Fertilizer	....	G.†	....	....	....	*1.65*	....	....	*10.00*	....
	Grange 1-8-2	....	G.†	....	....	....	*0.82*	....	....	*8.00*	*2.00*
	Grange 1-8-3	....	G.†	....	....	....	*0.82*	....	....	*8.00*	*3.00*
	Grange 2-8-2	....	G.†	....	....	....	*1.65*	....	....	*8.00*	*2.00*
	Grange 2-12-3	....	G.†	....	....	....	*1.65*	....	....	*12.00*	*3.00*
	High Grade Phosphate & Potash	....	G.†	....	....	....	....	....	....	*12.00*	*2.00*

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	American Agricultural Chem. Co.—Cont.										
	Michigan State Grange Brands—Cont.										
	Wheat Fertilizer Extra		*G.*†							*16.00*	
	Wheat Fertilizer No. 1		*G.*†							*14.00*	
	IX Fertilizer		*G.*†				*0.82*			*10.00*	
	Anaconda Copper Mining Co., Chicago, Ill.										
			G.†					*48.50*		*45.50*	
A 4941	Anaconda Treble Superphosphate	Grand Rapids	F.†					47.70	2.80	**44.90**	
	Armour Fertilizer Works, Chicago, Ill.										
			G.†				*1.65*	*10.50*		*10.00*	
A 5234	Ammoniated Phosphate No. 2	Blissfield	F.†	1.04	0.32	0.12	**1.48**	11.85	1.06	10.79	
			G.†					*10.50*		*10.00*	
A 5236	Cereal Phosphate	Blissfield	F.†					10.85	0.50	10.35	
			G.†				*1.65*	*8.50*		*8.00*	*2.00*
A 4877	Grain Grower	Coloma	F.†	1.22	0.38	0.10	1.70	9.05	0.48	8.57	2.00
A 4902	Grain Grower	Casnovia		1.23	0.35	0.16	1.74	9.25	0.64	8.61	2.08
A 5368	Grain Grower	Imlay City		1.10	0.26	0.15	**1.51**	9.35	0.58	8.77	2.25
		Average		1.18	0.33	0.14	1.65	9.22	0.57	8.65	2.11
			G.†				*0.82*	*8.50*		*8.00*	*1.00*
A 4742	Michigan Special	St. Johns	F.†	0.57	0.23	0.08	0.88	9.00	1.10	7.90	1.16
A 4777	Michigan Special	Ann Arbor		0.53	0.32	0.08	0.81	9.00	0.66	8.34	1.01
A 4945	Michigan Special	Caledonia		0.60	0.20	0.08	0.88	9.45	0.78	8.67	1.15
A 5366	Michigan Special	Imlay City		0.50	0.26	0.11	0.87	9.40	0.46	8.94	1.23
		Average		0.55	0.22	0.09	0.86	9.21	0.75	8.46	1.14
	1-10 Fertilizer		*G.*†				*0.82*			*10.00*	
	Phosphate & Potash Special		*G.*†							*10.00*	*1.00*

			G.†				1.67	8.50		8.00	1.00
A 4884	Special Grain Grower	Bridgman	F.†	1.30	0.28	0.09	1.67	9.45	0.62	8.83	1.20
			G.†				0.82	8.50		8.00	3.00
A 4776	Standard	Ann Arbor	F.†	0.51	0.25	0.04	0.83	8.85	0.62	8.23	2.37
A 4986	Standard	Bay City		1.28	0.27	0.05	1.60	9.40	0.52	8.88	2.92
A 5271	Standard	Hudson		0.63	0.25	0.06	0.94	9.60	0.52	9.08	2.19
A 5367	Standard	Imlay City		0.51	0.23	0.12	0.86	9.10	0.58	8.52	2.73
		Average		0.74	0.25	0.07	1.06	9.24	0.56	8.68	2.55
			G.†					14.00		14.00	
A 5414	Star Phosphate	Mt. Clemens	F.†					15.50	0.66	14.84	
			G.†				0.82	7.50		7.00	1.00
A 5415	Wheat, Corn & Oats Special	Mt. Clemens	F.†	0.75	0.22	0.05	1.02	9.10	0.46	8.64	1.20
	"Big Crop" Brands										
			G.†					16.50		16.00	
A 4778	Acid Phosphate	Ann Arbor	F.†					17.70	0.74	16.96	
A 4885	Acid Phosphate	Bridgman						17.30	0.66	16.64	
A 4889	Acid Phosphate	Buchanan						17.80	0.48	17.32	
A 5395	Acid Phosphate	Laingsburg						17.70	0.70	17.00	
		Average						17.63	0.65	16.98	
			G.†				1.65	27.00			
A 4779	Bone Meal	Ann Arbor	F.†	0.42	1.27	0.71	2.40	27.80			
A 4845	Bone Meal	Hudsonville		0.47	1.10	0.66	2.23	28.30			
		Average		0.45	1.18	0.69	2.32	28.05			
			G.†				0.82	8.50		8.00	8.00
A 4839	1-8-8 Fertilizer*	Hudsonville	F.†	0.71	0.25	0.07	1.03	7.50	0.38	7.12	7.22
			G.†				0.82	5.50		5.00	10.00
A 4837	1-5-10*	Hudsonville	F.†	1.01	0.31	0.10	1.45	7.85	0.48	7.37	3.85
			G.†				0.82	12.50		12.00	1.00
A 4841	1-12-1 Fertilizer	Hudsonville	F.†	0.64	0.21	0.10	0.95	12.70	0.34	12.36	1.20
A 5413	1-12-1 Fertilizer	Mt. Clemens		0.50	0.23	0.02	0.75	13.55	0.34	13.21	1.00
		Average		0.57	0.22	0.06	0.85	13.13	0.34	12.79	1.10
	2-8-6 Fertilizer		G.†				1.65	8.50		8.00	6.00
			G.†				1.65	8.50		8.00	8.00
A 4914	2-8-8 Fertilizer	Portage	F.†	1.49	0.33	0.08	1.81	9.60	0.46	9.14	9.05
			G.†				1.65	8.50		8.00	15.00
A 4915	2-8-15 Fertilizer	Portage	F.†	1.35	0.37	0.11	1.83	10.05	0.40	9.65	13.96

†Abbreviations for guaranteed and found.
*Shipped direct to consumer—unlicensed.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	Armour Fertilizer Works—Cont.										
	"Big Crop" Brands—Cont.										
			G.†	....	....	....	*1.65*	*10.50*	....	*10.00*	*4.00*
A 4840	2-10-4 Fertilizer	Hudsonville	F.†	1.19	0.36	0.12	1.67	11.00	0.90	10.10	4.10
A 4901	2-10-4 Fertilizer	Casnovia		1.16	0.33	0.15	1.64	11.75	0.88	10.87	4.22
		Average		1.17	0.35	0.14	1.66	11.38	0.89	10.49	4.16
			G.†	....	....	....	*1.65*	*12.50*	....	*12.00*	....
A 4883	2-12 Fertilizer	Bridgman	F.†	1.46	0.32	0.13	1.91	12.50	0.50	12.00	....
			G.†	....	....	....	*1.65*	*21.50*	....	*12.00*	*2.00*
A 4875	2-12-2 Fertilizer	Coloma	F.†	1.38	0.27	0.12	1.77	13.20	0.52	12.68	2.00
			G.†	....	....	....	*3.20*	*8.50*	....	*8.00*	*8.00*
A 4985	4-8-8 Fertilizer	Bay City	F.†	2.12	0.92	0.34	3.38	10.95	1.62	9.33	9.20
			G.†	....	....	....	*4.12*	*8.50*	....	*8.00*	*7.00*
A 4838	5-8-7 Fertilizer*	Hudsonville	F.†	0.81	0.30	0.11	1.22	8.90	0.54	8.36	8.61
			G.†	....	....	....	....	*10.50*	....	*10.00*	*8.00*
A 4888	10-8 Fertilizer	Buchanan	F.†	....	....	....	....	11.00	0.42	10.58	7.35
			G.†	....	....	....	....	*10.50*	....	*10.00*	*10.00*
A 4842	10-10 Fertilizer	Hudsonville	F.†	....	....	....	....	11.45	0.20	11.24	9.38
A 4876	10-10 Fertilizer	Coloma		....	....	....	....	11.55	0.20	11.35	9.30
		Average		....	....	....	....	11.50	0.20	11.30	9.34
			G.†	....	....	....	....	*12.50*	....	*12.00*	*2.00*
A 4843	12-2 Fertilizer	Hudsonville	F.†	....	....	....	....	12.50	0.50	12.00	2.04
A 5272	12-2 Fertilizer	Hudson		....	....	....	....	13.10	0.60	12.50	1.82
A 5233	12-2 Fertilizer	Blissfield		....	....	....	....	12.55	0.62	11.93	2.00
		Average		....	....	....	....	12.72	0.57	12.15	1.95
			G.†	....	....	....	....	*12.50*	....	*12.00*	*4.00*
A 4743	12-4 Fertilizer	St. Johns	F.†	....	....	....	....	12.85	0.56	12.29	4.06
A 4844	12-4 Fertilizer	Hudsonville		....	....	....	....	13.05	0.66	12.39	4.11
A 4966	12-4	Sunfield		....	....	....	....	13.50	0.58	12.92	4.27

A 5235	12-4 Fertilizer	Blissfield						12.90	0.57	12.33	4.10
A 5365	12-4 Fertilizer	Imlay City						13.30	0.42	12.88	3.29
A 5394	12-4 Fertilizer	Laingsburg						13.60	0.52	13.08	4.11
		Average						13.20	0.55	12.65	3.99
A 4882	Kainit*	Bridgman	G.†								*14.00*
			F.†								14.62
	Tuscarora Brands										
A 4887	Acid Phosphate	New Buffalo	G.†					*14.50*		*14.00*	
			F.†					14.80	0.46	14.34	
	16% Acid Phosphate		G.†							*16.00*	
A 5410	Potash & Phosphate	Utica	G.†					*10.50*		*10.00*	*1.00*
			F.†					12.35	0.34	12.01	0.83
A 4886	Special Corn, Wheat & Bean Grower	New Buffalo	G.†				*0.82*	*8.50*		*8.00*	*1.00*
			F.†	0.48	0.27	0.04	0.79	9.25	0.96	8.29	1.09
A 5409	Special Corn, Wheat & Bean Grower	Utica		0.58	0.22	0.07	0.87	8.85	0.86	7.99	1.28
		Average		0.53	0.25	0.05	0.83	9.05	0.91	8.14	1.19
	The Barrett Co., New York, N. Y.										
A 4741	Arcadian Sulphate of Ammonia	Tecumseh	G.†				*20.75*				
			F.†				21.32				
A 4846	Arcadian Sulphate of Ammona	Fennville					21.31				
		Average					21.31				
	R. Binder & Co., Battle Creek, Mich.										
A 5019	Blood & Bone	Battle Creek	G.†				*5.25*	*13.17*			
			F.†	2.32	2.00	0.99	5.31	19.70			
	N. Burleson, Swartz Creek, Mich.										
A 5289	Economy	Swartz Creek	G.†				*1.65*			*10.00*	*2.00*
			F.†	1.14	0.44	0.19	1.77	12.68	3.01	9.67	2.52
	E. Burton Fertilizer Works, St. Joseph, Mich.										
A 4881	Meat & Bone Phosphate	St. Joseph	G.†				*4.75*	*14.00*		*6.00*	
			F.†	0.84	2.67	1.33	4.84	12.70	6.50	6.20	
	Calumet Fertilizer Co., New Albany, Ind.										
A 5478	Bone Phosphate & Potash Mixture	Millington	G.†				*0.41*	*11.00*		*10.00*	*1.00*
			F.†	0.21	0.12	0.12	0.45	10.80	0.71	10.09	0.99
A 5450	Coburn's Special with Potash	Kingston	G.†				*0.60*	*9.50*		*8.50*	*0.50*
			F.†	0.34	0.14	0.06	0.54	9.10	0.44	8.66	0.69
A 5397	Corn & Wheat Special	Mason	G.†				*1.62*	*11.00*		*10.00*	*2.00*
			F.†	1.34	0.22	0.22	1.78	12.85	1.06	11.79	2.13

†Abbreviations for guaranteed and found
*Shipped under 1920 license.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	Calumet Fertilizer Co.—Cont.										
	Extra Ammoniated Bone Phosphate		G.†				*1 64*			*12 00*	
	Grape Special		G.†				*0.82*	*20 00*			*8.00*
A 5345	Onion & Beet Grower	Mt. Morris	G.†				*0 82*	*9 00*		*8 00*	*3 00*
			F.†	0 48	0 18	0 24	0.90	9 55	1 26	8 92	3 15
A 4704	Onion & Potato Grower	Union City	G.†				*1 62*	*9 00*		*8.00*	*6 00*
			F.†	1 08	0 25	0 26	1 59	9 85	2 36	**7 49**	7 76
A 5451	Onion & Potato Grower	Kingston		0 83	0 25	0 20	**1 28**	10 58	2 51	8 07	8 04
		Average		0 96	0 25	0 23	**1 44**	10 22	2 44	**7 78**	7.90
A 4763	Phosphate & Potash	Grand Blanc	G.†					*11 00*		*10 00*	*2 00*
			F.†					10 75	0 88	9 87	2 09
A 4922	Phosphate & Potash	Zeeland						11 10	0 62	10 48	2 01
A 5339	Phosphate & Potash	Flushing						10 60	0 46	10 14	2 01
		Average						10 82	0 65	10.17	2 04
A 5341	Ten Four	Flushing	G.†					*11 00*		*10 00*	*4 00*
			F.†					11 80	1 38	10 42	4 00
A 5344	Ten Four	Mt. Morris						11 18	1 84	**9 34**	4 04
		Average						11 49	1 61	9 88	4.02
A 4921	Ten Ten Hummer	Zeeland	G.†					*11 00*		*10 00*	*10 00*
			F.†					12 05	3 57	**8 48**	10 03
A 5346	Ten Ten Hummer	Mt. Morris						11 93	3 23	**8 70**	10.17
		Average						11 99	3 40	**8 59**	10.10
	Twelve Two		G.†							*12 00*	*2.00*
	Two-Eight Two		G.†				*1 64*			*8.00*	*2 00*
A 5347	14% Acid Phosphate*	Mt. Morris	G.†					*15 00*		*14 00*	
			F.†					15 60	0 24	15.26	

A 5340	16% Acid Phosphate	Flushing	G.†					17.00		16.00	
			F.†					18.60	0.02	18.58	
A 5016	Half-Seven-Ten*	Neeley	G.†				0.41	8.00		7.00	10.00
			F.†	0.27	0.08	0.09	0.04	8.35	1.54	6.81	10.20
			G.†				0.41	9.00		8.00	3.00
A 4923	Half-Eight-Three*	Zeeland	F.†	0.25	0.10	0.11	0.46	9.95	1.44	8.51	2.97
A 5218	Half-Eight-Three*	Dundee		0.37	0.09	0.08	0.54	9.13	1.51	7.62	3.01
		Average		0.31	0.10	0.09	0.50	9.54	1.48	8.06	2.99
	Cincinnati Plant Food Co., Cincinnati, Ohio										
A 5461	Nurto Pulverized Sheep Manure	Dearborn	G.†				2.00	1.00			1.59
			F.†	0.48	0.38	1.15	2.01	1.35			2.42
	Columbia Guano Company, Toledo, Ohio										
	Columbia 16% Acid Phosphate		G.†							16.00	
	Columbia Bountiful Guano		G.†				1.60			12.00	2.00
	Columbia Glory Brand		G.†				0.80			12.00	
	Columbia Goodwill Guano		G.†				0.80			8.00	1.00
	Columbia Special Fish Guano		G.†				0.80			11.00	2.00
	Columbia 12-2 Phosphate and Potash		G.†							12.00	2.00
	Darling & Company, Chicago, Ill.										
			G.†							16.00	
A 4728	16% Acid Phosphate	Tecumseh	F.†					18.15	2.16	15.99	
A 5242	16% Acid Phosphate	Brighton						19.00	2.88	16.12	
		Average						18.58	2.52	16.06	
			G.†				0.82	10.00		8.00	10.00
A 4186	Big Potash	Grand Rapids	F.†	0.17	0.31	0.32	0.80	10.95	2.42	8.53	10.14
A 4729	Big Potash	Tecumseh		0.21	0.29	0.36	0.86	10.90	1.68	9.22	10.04
A 4879	Big Potash	Benton Harbor		0.20	0.25	0.34	0.79	10.80	1.82	8.98	8.47
A 5369	Big Potash	Imlay City		0.10	0.31	0.39	0.80	12.00	2.18	9.82	10.01
A 5393	Big Potash	Laingsburg		0.26	0.28	0.32	0.86	11.10	1.68	9.42	10.79
		Average		0.19	0.29	0.34	0.82	11.15	1.96	9.19	9.89
A 5436	Bone & Acid Phosphate ½ and ½	Frankenmuth	G.†				0.82	23.00		12.00	
			F.†	0.47	0.53	0.24	1.24	24.95	13.35	11.60	
			G.†				1.65	10.00		8.00	2.00
A 4730	Chicago Brand	Tecumseh	F.†	0.93	0.44	0.26	1.63	10.75	1.50	9.25	2.06
A 4760	Chicago Brand	Flint		0.89	0.45	0.32	1.66	10.65	1.90	8.75	2.10
		Average		0.91	0.45	0.29	1.65	10.70	1.70	9.00	2.08

†Abbreviations for guaranteed and found.
*Shipped under 1920 license.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Darling & Co.—Cont.										
			G.†	....	....	....	*2 47*	*10 00*	....	*8 00*	*4 00*
A 4187	Farmer's Favorite	Grand Rapids	F.†	0 33	0 92	0 41	1 66	12.25	2 02	10 23	3.10
A 4793	Farmer's Favorite	Ypsilanti		1 01	0 68	0 44	2 13	11 65	2 06	9 59	3 87
A 4880	Farmer's Favorite	Benton Harbor		0 91	0 89	0 50	2 30	11 20	1 82	9.38	3.45
		Average		0 75	0 83	0 45	2 03	11.70	1.97	9.73	3.47
			G.†	....	....	....	*1 65*	*14 00*	....	*12.00*	....
A 5400	General Crop	Morenci	F.†	1 01	0 44	0 21	1 66	14 40	0 88	13.52	....
			G.†	....	....	....	*0 82*	*11.00*	....	*9 00*	*1.00*
A 4185	Grain Grower	Grand Rapids	F.†	0.59	0 28	0 41	1 28	11 60	2 10	9 50	2 09
A 4732	Grain Grower	Tecumseh		0 46	0 29	0 13	0 88	12 75	2.02	10.73	1.31
A 5399	Grain Grower	Morenci		0 69	0 30	0 12	1 11	13 05	1.68	11.37	1.06
		Average		0 58	0 29	0 22	1 09	12.47	1.93	10.54	1.49
			G.†	....	....	....	*0 82*	*12.00*	....	*10 00*	....
A 5036	Little Giant	Holland	F.†	0 34	0.36	0 24	0 94	12 75	1.15	11.60	....
			G.†	....	....	....	....	....	....	....	*50.00*
A 4794	Muriate of Potash	Ypsilanti	F.†	....	....	....	....	....	....	....	51.22
			G.†	....	....	....	*1 85*	....	....	*1.00*	*1.00*
A 4188	Pulverized Sheep Manure	Grand Rapids	F.†	0 72	0 42	1 12	2 26	1.85	0 12	1.73	2.08
A 4759	Pulverized Sheep Manure	Flint		0 49	0 50	1 34	2 33	2 40	0 72	1 68	1.38
A 4946	Pulverized Sheep Manure	Grand Rapids		1 02	0 62	1 49	3.13	1 09	1.08	0.01	0.74
		Average		0.74	0 51	1.32	2 57	1.78	0.64	1.14	1.40
			G.†	....	....	....	*1.85*	*28 00*	....	....	....
A 4758	Pure Ground Bone	Flint	F.†	0 15	1.19	0 71	2 05	28.10	....	....	....
			G.†	....	....	....	*0 82*	*10 00*	....	*8.00*	*3.00*
A 4731	Sure Winner	Tecumseh	F.†	0 20	0 30	0 33	0 83	10 75	1.80	8 95	2.84
A 5270	Sure Winner	Hudson		0 24	0 33	0 37	0 94	10.35	1.92	8.43	3.16
A 5427	Sure Winner	Montrose		0 12	0 37	0 39	0 88	10 85	1.74	9 11	3.03
		Average		0 19	0 33	0 36	0 88	10 65	1 82	8.83	3.01

			G.†					10 00		10 00	5 02
A 5392	Ten Five	Laingsburg	F.†					13.55	2.78	10 77	4 47
A 5417	Ten Five	New Haven						13 15	1 24	11 91	4.26
		Average						13.25	2.01	11.34	4 34
	The Diamond Fertilizer Co., Sandusky, Ohio										
			G.†					17 00		16 00	
A 4834	Diamond Acid Phosphate	Alto	F.†					17 30	1 08	16 22	
A 5207	Diamond Acid Phosphate	Ypsilanti						17 60	1 74	15 86	
A 5418	Diamond Acid Phosphate	Richmond						16 80	0 99	15 81	
		Average						17 23	1.27	15.96	
	Diamond Ammoniated Phosphate		G.†				1 65			10.00	
			G.†					11.00		10 00	4 00
A 5343	Diamond Black Soil Special	Mt. Morris	F.†					10 98	0 98	10 00	3.65
			G.†				1 65	13 00		12 00	2.00
A 5456	Diamond Economy Brand	Saline	F.†	1 28	0 20	0 08	1.56	13 30	1.29	12 01	2 04
			G.†				0 41	11 00		10 00	1 00
A 4835	Diamond General Grower	Alto	F.†	0 34	0 08	0 00	0 42	11 15	0 82	10 33	1 01
A 5206	Diamond General Grower	Ypsilanti		0 26	0 10	0 03	0 39	11 00	0 88	10 12	1 00
A 5231	Diamond General Grower	Blissfield		0 37	0 08	0 00	0 45	10 95	0 90	10 05	0 89
		Average		0 32	0 09	0 01	0.42	11 03	0 87	10 16	0 97
			G.†				0 82	11 00		10.00	1.00
A 5224	Diamond Guano	Deerfield	F.†	0 60	0 13	0 01	0 74	10.85	0 88	9 97	1.13
			G.†				0.41	13 00		12 00	
A 4836	Diamond Phosphate & Humus	Alto	F.†	0 26	0 12	0 06	0 44	14 00	1 01	12 96	
A 5225	Diamond Phosphate & Humus	Deerfield		0 32	0 17		0.49	14 00	1 51	12 49	
A 5269	Diamond Phosphate & Humus	Hudson		0 24	0 18	0 02	0 44	13 80	0 98	12 82	
		Average		0 27	0 16	0 03	0 46	13 93	1 18	12 75	
			G.†					11 00		10 00	2 00
A 5342	Diamond Phosphate & Potash	Mt. Morris	F.†					11 15	1 17	9 98	2 00
			G.†				0 82	9 00		8 00	4 00
A 5208	Diamond Truck Special	Ypsilanti	F.†	0 64	0 10	0 03	0 77	9 10	0 56	8 54	3 84
A 5229	Diamond Truck Special	Blissfield		0 80	0 10		0 90	8 65	0 70	7 95	4 11
		Average		0 72	0 10	0 02	0 84	8 88	0 63	8 25	3.98
			G.†				0 82	10 00		9 00	7.00
A 5268	Extra Truck Special	Hudson	F.†	0 73	0 10		0 83	10.65	0	9 83	6.21

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at	Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	Earp-Thomas Cultures Corp., New York,, N. Y.									
	Stimuplant Tablets	G.†				*11 00*			*12.00*	*15.00*
	Elliot, The Florist, Gary, Ind.									
	Elliott's Plant Food	G.†				*3 70*			*7.50*	*6 50*
	Federal Chemical Co., Louisville, Ky.									
		G.†				*0 82*			*12 00*	
A 5035	A-1 Fertilizer	Jamestown F.†	0 28	0.33	0 22	0.83	13 05	0 70	12.35	
	A-1 Formula	G.†				*1 65*			*10 00*	
		G.†							*12 00*	*4 00*
A 5021	Black Land Special	Kent City F.†					12 43	0 88	11 55	3 03
A 5475	Black Land Special	Chesaning					11 85	0.66	11 19	3 58
		Average					12 14	0.77	11.37	3 33
		G.†				*0 82*			*11 00*	*3 00*
A 4860	Braden Formula	Wayland F.†	0 71	0 10	0 07	0 91	11 90	0 72	11 18	2 67
A 4864	Braden Formula	South Haven	0 60	0 10	0 10	0 80	11 60	0 64	10 96	2 49
A 5024	Braden Formula	Moline	0 57	0 10	0 14	0 81	11 63	0 66	10 97	2 56
A 5031	Braden Formula	Burr Oak	0 59	0 08	0 16	0 83	11 35	0 58	10 77	3 00
		Average	0 63	0.09	0 12	0 84	11.62	0 65	10.97	2.68
	Daybreak Champion Potash Fertilizer	G.†							*8.00*	*2 00*
		G.†				*0 82*			*11 00*	*3 00*
A 5388	Daybreak Favorite	Vernon F.†	0 46	0 17	0 21	0 81	12 15	1 16	10.99	2 18
	1st Prize Formula	G.†				*0 82*			*11.00*	*3.00*
	Globe Tip Top Potash Fertilizer	G.†							*8 00*	*2.00*
	Half & Half Meal Mixture	G.†				*1 65*			*10.00*	

			G.†				*1.65*			*12.00*	
A 5026	High Grade Fertilizer	Richland	F.†	0.31	0.17	0.08	0.56	14.20	0.88	13.32	
			G.†							*16.00*	
A 4197	High Grade Phosphate	Zeeland	F.†					15.70	0.43	15.27	
A 4824	High Grade Phosphate	Nunica						16.95	0.30	16.65	
A 4849	High Grade Phosphate	Fennville						17.80	0.62	17.18	
A 4926	High Grade Phosphate	Grand Rapids						17.00	0.38	16.62	
75 A 5380	High Grade Phosphate	Romeo						17.20	0.20	17.00	
A 5390	High Grade Phosphate	Vernon						18.20	0.30	17.90	
		Average						17.14	0.37	16.77	
	Liberty Grain Grower		G.†				*0.41*			*10.00*	
			G.†				*1.65*			*12.00*	*2.00*
A 4861	Loam Land Fertilizer**	Wayland	F.†				**0.18	**10.05	**0.54	**9.51	**6.74
A 4900	Loam Land Fertilizer	Kent City		1.44	0.04	0.11	1.59	12.55	0.54	12.01	1.22
A 4937	Loam Land Fertilizer	Rockford		0.75	0.19	0.19	1.13	13.63	0.42	13.21	1.81
A 5028	Loam Land Fertilizer	Richland		1.19	0.08	0.06	1.33	12.40	0.86	11.34	1.42
A 5030	Loam Land Fertilizer	Burr Oak		0.53	0.08	0.10	0.71	11.90	0.62	11.28	2.51
		Average		0.98	0.10	0.11	1.19	12.62	0.61	12.01	1.74
			G.†				*0.41*			*11.00*	*1.00*
A 5359	Michigan Bean & Beet Special	Lapeer	F.†	0.02	0.17	0.22	0.41	10.95	0.56	10.39	1.09
A 5391	Michigan Bean & Beet Special	Vernon		0.11	0.15	0.26	0.52	11.55	1.16	10.39	1.42
		Average		0.07	0.16	0.21	0.47	11.25	0.86	10.39	1.26
			G.†				*1.65*			*10.00*	*4.00*
A 4859	Mid-West High Grade Mixture	Wayland	F.†	0.58	0.11	0.07	0.76	10.30	0.68	9.62	6.06
A 4863	Mid-West High Grade Mixture	South Haven		0.91	0.07	0.08	1.06	11.65	0.84	10.81	1.78
A 5022	Mid-West High Grade Mixture	Moline		1.05	0.13	0.22	1.40	11.05	0.78	10.27	3.04
A 5025	Mid-West High Grade Mixture	Richland		0.47	0.07	0.11	0.65	9.40	0.80	8.60	4.01
A 5033	Mid-West High Grade Mixture	Bronson		0.85	0.09	0.15	1.09	10.80	0.82	9.98	4.16
		Average		0.77	0.09	0.13	0.99	10.64	0.78	9.86	3.81
	Mogul Potash Fertilizer		G.†							*8.00*	*2.00*
	Nitro-Phosphate		G.†				*0.41*			*15.00*	
			G.†							*10.00*	*2.00*
A 4196	Potash Special	Zeeland	F.†					10.80	0.70	10.10	1.59
A 5360	Potash Special	Lapeer						10.05	0.60	9.45	1.56
A 5379	Potash Special	Romeo						10.30	0.44	9.86	2.01
A 5455	Potash Special	Vernon						10.65	0.60	10.05	1.42
		Average						10.45	0.59	9.86	1.65

†Abbreviations for guaranteed and found.
**Not included in average.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at	Nitrogen.				Phosphoric acid.			Potash.
			As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	Federal Chemical Co.—Cont.									
		G.†				*1 00*	*30 00*			
A 5041	Pure Bone	Coloma F.†	0.29	0 45	0 38	1 12	31.70			
	Royal Phosphate	G.†							*14 00*	
		G.†				*0.82*			*10 00*	*2.00*
A 4200	Special Manure	Grand Rapids F.†	0 67	0 09	0 08	0 84	10 85	0.58	10 27	2.00
A 5027	Special Manure	Richland	0 62	0 13	0 15	0 90	10 65	0 64	10 01	1 77
A 5389	Special Manure	Vernon	0.34	0 20	0 29	0.83	10 93	1 06	9 87	2.02
A 5411	Special Manure	Utica	0 23	0 37	0 22	0.72	10 45	0 44	10 01	1.85
A 5454	Special Manure	Vernon	0 42	0 10	0 08	0 60	10.50	0 60	9 90	2.21
		Average	0.46	0.16	0 16	0.78	10.68	0.66	10.02	1.97
		G.†					*20 00*		*10 00*	
A 4976	Special Phosphate Mixture	Middleton F.†					21.30	9 60	11 70	
A 5253	Special Phosphate Mixture	Monroe					21 70	9.65	12.05	
A 5453	Special Phosphate Mixture	Vernon					19 30	5.90	13.40	
		Average					20.77	8.38	12.39	
		G.†				*0.82*			*8 00*	*4.00*
A 4924	Standard Crop & Tobacco Grower	Zeeland F.†	0 44	0.14	0 23	0 81	8.65	0 36	8.29	4.04
A 5449	Standard Crop & Tobacco Grower	Mayville	0.39	0 11	0 17	0 67	10.65	0.54	10.11	3 32
		Average	0.41	0 13	0 20	0.74	9.65	0.45	9.20	3.68
	Standard Meal Mixture	G.†				*0.82*			*10.00*	
		G.†				*0 41*			*11.50*	*0.50*
A 4938	Standard Wheat & Corn Maker	Rockford F.†	0 23	0 09	0 09	0 41	10.28	0.74	9 54	1 39
A 5361	Standard Wheat & Corn Maker	Lapeer	0 19	0 15	0 14	0 48	11.33	0.46	10.87	0 66
A 5412	Standard Wheat & Corn Maker	Utica	0 13	0 09	0 12	0 34	13.10	0.46	12 64	0.66
		Average	0.18	0 11	0.12	0 41	11.57	0.55	11.02	0.90

			G.†					12.00		6.00	10.00
A 4199	10% Potash Fertilizer	Grand Rapids	F.†					11.80	2.42	9.38	6.48
A 4925	10% Potash Fertilizer	Grand Rapids						12.60	1.68	10.92	5.89
		Average						12.20	2.05	10.15	6.19
			G.†							10.00	10.00
A 4198	Ten Ten Potash Fertilizer	Zeeland	F.†					11.50	0.82	10.68	7.09
A 4848	Ten Ten Potash Fertilizer	Fennville						10.60	0.91	9.69	8.90
A 4862	Ten Ten Potash Fertilizer	Wayland						10.90	0.60	10.30	8.88
A 4920	Ten Ten Potash Fertilizer	Zeeland						12.15	0.76	11.39	7.20
A 4939	Ten Ten Potash Fertilizer	Rockford						11.80	0.76	11.04	5.97
A 5023	Ten Ten Potash Fertilizer	Moline						10.80	0.60	10.20	7.19
A 5029	Ten Ten Potash Fertilizer	Burr Oak						12.50	0.84	11.66	6.29
A 5032	Ten Ten Potash Fertilizer	Bronson						10.83	1.02	9.81	9.50
		Average						11.39	0.79	10.60	7.63
			G.†				0.82			12.00	1.00
A 4899	Wheat & Grain Special	Kent City	F.†	0.71	0.11	0.11	0.93	12.70	0.56	12.14	1.22
A 4975	Wheat & Grain Special	Middleton		0.63	0.11	0.10	0.87	12.53	0.60	11.93	1.21
		Average		0.67	0.12	0.11	0.90	12.62	0.58	12.01	1.22
	Gleaner Clearing House Assn., Grand Rapids, Mich.										
	Gleaner 14% Acid Phosphate		G.†							14.00	
			G.†					16.50		16.00	
A 5288	Gleaner 16% Acid Phosphate	Swartz Creek	F.†					17.80	0.26	17.51	
	Gleaner Ammonia & Phosphoric Acid		G.†				1.65			10.00	
			G.†				0.82	10.50		10.00	1.00
A 5465	Gleaner Bean & Corn Grower	Danville	F.†	0.62	0.23	0.05	0.90	11.90	0.62	11.28	1.90
	Gleaner General Grower		G.†				0.82			8.00	1.00
	Gleaner Grain Grower		G.†				1.65			8.00	1.00
	Gleaner Grain Special		G.†				1.65			10.00	1.00
			G.†					10.50		10.00	2.00
A 5017	Gleaner Phosphoric Acid & Potash	Doster	F.†					9.50	0.48	9.02	1.59
A 5287	Gleaner Phosphoric Acid & Potash	Swartz Creek						10.60	0.46	10.14	2.02
		Average						10.05	0.47	9.58	1.81
			G.†				0.82	8.50		8.00	2.00
A 5286	Gleaner Wolverine Pride	Swartz Creek	F.†	0.91	0.31	0.10	1.32	10.20	0.96	9.24	1.16

†Abbreviations for guaranteed and fouhd.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	Groves Fertilizer Works, Cincinnati, Ohio										
	16% Acid Phosphate		G.†							16 00	
	Ammoniated Phosphate		G.†				1 64			12 00	
	Bone & Phosphate		G.†				0 82	20 00			
	Corn & Tobacco		G.†							10 00	2.00
	Economy Brand		G.†				0 82			10 00	1.00
	Grain Grower		G.†				0 82			12 00	
	Groves Standard		G.†				1 64			10.00	2 00
	Half and Half		G.†				1 64	16 00			2.00
	Harvest King		G.†				0 82			8 00	1.00
	Monarch Brand		G.†							14 00	
	Perfect Driller		G.†				0 41	16 00			
	Phosphate & Potash		G.†							10 00	4 00
	10% Potash Fertilizer		G.†				0 82			5.00	10.00
	International Agricultural Corp., Buffalo, N. Y.										
	Buffalo Brands										
A 5038	Ammoniated Phosphate	Allegan	G.†				1 20	13 00		12.00	
			F.†	0 66	0 44	0 22	1 32	14 10	2 20	11.90	
A 5468	Crop Producer	Brooklyn	G.†				1 60	13 00		12 00	2 00
			F.†	0.84	0 39	0 41	1 64	14 80	2.16	12.64	2 36
A 4971	Economy	Hart	G.†				1 60	9 00		8 00	2.00
			F.†	0 81	0 39	0 31	1.51	9 95	1.92	8.03	2.13
	Farmers Choice		G.†				8 80			10 00	2.00

	International Agricultural Corp.—Cont.										
	Buffalo Brands—Cont.										
			G.†				*0.80*	*9.00*		*8.00*	*1.00*
A 4944	General Favorite	Caledonia	F.†	0.43	0.23	0.18	0.84	10.15	1.44	8.71	1.23
A 5407	General Favorite	Utica		1.36	0.21	0.21	1.78	10.10	1.58	8.52	1.47
		Average		0.90	0.22	0.19	1.31	10.13	1.51	8.62	1.35
			G.†					*19.00*		*18.00*	
A 5037	High Grade Acid Phosphate	Allegan	F.†					19.50	1.14	18.36	
A 5467	High Grade Acid Phosphate	Brooklyn						20.90	1.94	18.96	
		Average						20.20	1.95	18.66	
			G.†				*1.60*	*11.00*		*10.00*	*4.00*
A 5466	Ideal	Brooklyn	F.†	1.09	0.41	0.31	1.81	13.80	2.62	11.18	4.12
			G.†					*13.00*		*12.00*	*2.00*
A 5363	Phosphate & Potash	Dryden	F.†					14.00	1.46	12.51	2.01
			G.†					*17.00*		*16.00*	
A 4943	Sixteen Per Cent	Caledonia	F.†					19.50	2.06	17.14	
			G.†					*11.00*		*10.00*	*8.00*
A 4917	Ten Eight	Portage	F.†					11.70	0.92	10.78	8.38
A 5362	Ten Eight	Dryden						11.85	1.00	10.85	8.45
A 5416	Ten Eight	Mt. Clemens						11.75	0.94	10.81	8.07
		Average						11.77	0.95	10.82	8.30
	Three Eight One		*G.*†				*2.50*			*8.00*	*1.00*
			G.†				*0.80*	*9.00*		*8.00*	*4.00*
A 4972	Tip Top	Hart	F.†	0.41	0.23	0.16	0.80	9.30	1.20	8.10	4.25
A 5364	Tip Top	Dryden		0.37	0.24	0.22	0.83	9.60	1.22	8.38	4.00
A 5408	Tip Top	Utica		0.49	0.20	0.17	0.86	9.60	1.56	8.01	4.33
		Average		0.43	0.22	0.18	0.83	9.50	1.33	8.17	4.19
			G.†				*1.60*	*9.00*		*8.00*	*10.00*
A 4808	Two Eight Ten	Hudsonville	F.†	0.87	0.37	0.32	1.56	9.65	1.56	8.09	17.10
			G.†				*2.50*	*9.00*		*8.00*	*6.00*
A 5039	Vegetable & Potato	Kalamazoo	F.†	1.61	0.54	0.26	2.41	9.60	1.60	8.00	6.10
	I. A. C. Brands										
			G.†					*17.00*		*16.00*	
A 4940	Acid Phosphate	Rockford	F.†					19.20	2.18	17.02	
	Alkaline		*G.*†							*12.00*	*2.00*

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	I. A. C. Brands—Cont.										
	Corn & Grain		G.†	....	....	....	*1.60*	....	....	*12.00*	....
	Crop Producer		G.†	....	....	....	*1.60*	....	....	*12.00*	*2.00*
	Early Harvest		G.†	....	....	....	*1.60*	....	....	*10.00*	*4.00*
	Steamed Bone		G.†	....	....	....	*0.80*	*29.00*	....	....	....
	Nitrate Soda		G.†	....	....	....	*15.00*	....	....	....	....
	The Jarecki Chemical Co., Sandusky, Ohio										
			G.†	....	....	....	....	....	....	*16.00*	....
A 4830	Acid Phosphate	Conklin	F.†	....	....	....	....	17.50	0.84	16.66	....
A 4950	Acid Phosphate	Belding		....	....	....	....	18.50	1.42	17.08	....
A 5222	Acid Phosphate	Petersburg		....	....	....	....	17.30	0.60	16.70	....
		Average		....	....	....	....	17.77	0.95	16.82	....
			G.†	....	....	....	*0.82*	*11.00*	....	*10.00*	....
A 5443	Ammoniated Phosphate	Reese	F.†	0.36	0.35	0.09	0.80	11.90	1.90	10.00	....
	Bone Meal		G.†	....	....	....	*1.65*	*27.00*	....	....	....
			G.†	....	....	....	*2.50*	*24.00*	....	....	....
A 5426	Bone Meal	Mason	F.†	0.85	1.36	0.13	3.14	22.60	....	....	....
	Bone Meal & Acid Phosphate		G.†	....	....	....	*1.25*	....	....	*10.00*	....
			G.†	....	....	....	*1.65*	*13.00*	....	*12.00*	....
A 5424	Clay Soil Special	Mason	F.†	1.49	0.21	0.07	1.77	14.40	1.18	13.22	....
A 5411	Clay Soil Special	Reese		1.39	0.19	0.12	1.70	14.35	1.00	13.35	....
		Average		1.44	0.20	0.10	1.74	11.38	1.09	13.29	....
	C. O. D. Phosphate		G.†	....	....	....	....	....	....	*14.00*	....
A 4810	High Potash Manure	Hudsonville	F.†	1.54	0.15	0.26	1.95	9.95	2.77	7.18	10.23

The Jarecki Chemical Co.—Cont,

			G.†				*0.82*	*12.90*		*11.00*	*1.00*
A 4750	Lake Erie Guano with Phosphate and Potash	Ovid	F.†	0.63	0.10	0.10	0.83	12.90	1.42	11.48	1.03
A 4831	Lake Erie Guano with Phosphate and Potash	Conklin		0.93	0.23	0.06	1.22	12.15	1.02	11.13	1.45
A 4947	Lake Erie Guano with Phosphate and Potash	Belding		0.65	0.15	0.10	0.90	13.80	2.46	11.34	1.00
A 5423	Lake Erie Guano with Phosphate and Potash	Mason		0.58	0.17	0.12	0.87	13.50	2.06	11.41	1.00
		Average		0.70	0.16	0.10	0.96	13.09	1.74	11.35	1.12
			G.†				*0.41*	*11.00*		*10.00*	*1.00*
A 4752	Little Giant	Ovid	F.†	0.35	0.07	0.07	0.49	11.80	1.14	10.66	0.87
A 4949	Little Giant	Belding		0.32	0.07	0.10	0.49	12.25	1.16	11.09	1.00
A 5230	Little Giant	Blissfield		0.43	0.07	0.10	0.60	11.60	1.10	10.50	0.85
A 5256	Little Giant	La Salle		0.41	0.03	0.08	0.52	11.35	1.42	9.93	0.65
		Average		0.38	0.06	0.09	0.53	11.75	1.20	10.55	0.84
			G.†				*1.65*	*13.00*		*12.00*	*2.00*
A 4751	Middle West Formula	Ovid	F.†	1.23	0.11	0.21	1.55	14.20	1.52	12.68	2.01
A 4809	Middle West Formula	Hudsonville		1.28	0.14	0.18	1.60	14.08	2.18	11.90	2.40
		Average		1.25	0.13	0.20	1.58	14.14	1.85	12.29	2.21
			G.†				*0.82*	*9.00*		*8.00*	*2.00*
A 4948	Number One Formula	Belding	F.†	0.68	0.04	0.11	0.83	9.40	1.16	8.24	2.01
A 4942	Number One Formula	Dutton		0.68	0.05	0.10	0.83	9.60	1.00	8.60	2.05
A 5351	Number One Formula	Davison		0.58	0.06	0.12	0.76	9.65	1.10	8.55	2.00
A 5448	Number One Formula	Vassar		0.69	0.06	0.11	0.86	9.80	1.04	8.76	2.05
		Average		0.66	0.05	0.11	0.82	9.61	1.08	8.53	2.03
			G.†				*0.82*	*10.00*		*9.00*	*7.00*
A 5223	One-Nine-Seven	Petersburg	F.†	0.83	0.06	0.12	1.01	10.43	2.61	7.82	7.54
	Phosphate with Humus		G.†				*0.41*			*12.00*	
			G.†				*0.41*	*11.00*		*10.00*	*1.00*
A 4948	Special Sugar Beet Grower	Mt. Pleasant	F.†	0.38	0.07	0.10	0.55	12.45	1.12	13.33	1.02
			G.†					*11.00*		*10.00*	*1.00*
A 5349	Square Brand Phosphate & Potash	Davison	F.†					13.10	1.40	11.70	2.80
A 5440	Square Brand Phosphate & Potash	Reese						11.75	1.82	9.93	2.22
		Average						12.43	1.61	10.82	2.51
			G.†					*11.00*		*10.00*	*4.00*
A 5350	Super Phosphate and Potash	Davison	F.†					12.40	1.58	10.82	3.77
A 5431	Super Phosphate and Potash	Clio						11.95	1.34	10.61	4.12
A 5442	Super Phosphate and Potash	Reese						11.83	1.42	10.43	3.66
		Average						12.06	1.44	10.62	3.85

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	The Jarecki Chemical Co.—Cont.										
			G.†				*0.82*	*9.00*	...	*8.00*	*4.00*
A 5425	Tobacco and Potato Food	Mason	F.†	0.81	0.09	0.12	1.02	10.55	2.00	8.55	4.27
A 5435	Tobacco and Potato Food	Bridgeport		0.68	0.12	0.22	1.02	9.55	2.46	7.09	4.54
		Average		0.75	0.10	0.17	1.02	10.05	2.23	7.82	4.41
			G.†					*9.00*	...	*8.00*	*10.00*
A 4807	Truck Special	Hudsonville	F.†					10.55	2.44	8.11	10.44
	The Michigan Humus & Chemical Co., Chassel, Mich.										
	Humasoil		G.†				*0.75*		...	*0.01*	*0.05*
	Michigan State Farm Bureau, Lansing, Mich.										
			G.†					*17.00*		*16.00*	...
A 4781	Acid Phosphate	Saline	F.†					18.00	1.64	16.36	
A 4913	Acid Phosphate	Plainwell						19.10	2.06	17.04	
A 4962	Acid Phosphate	Charlotte						19.60	1.52	18.08	
A 5210	Acid Phosphate	Milan						17.50	1.02	16.48	
		Average						18.55	1.56	16.99	...
			G.†					*9.00*	...	*8.00*	*10.00*
A 4785	Black Land Special	Saline	F.†					8.85	0.80	8.05	11.64
A 4908	Black Land Special	Allegan						10.00	0.92	9.08	10.74
A 4912	Black Land Special	Plainwell						9.65	0.96	8.69	10.41
A 5214	Black Land Special	Azalia						9.55	1.04	8.51	1.48
		Average						9.51	0.93	8.58	10.82
			G.†				*1.60*	*13.00*	...	*12.00*	
A 4784	Clay Soil Special	Saline	F.†	0.91	0.35	0.24	1.50	11.50	2.26	12.24	
A 5213	Clay Soil Special	Azalia		1.18	0.40	0.19	1.77	14.65	2.22	12.43	
		Average		1.04	0.38	0.22	1.64	14.58	2.24	12.34	

			G.†				1 60	13 00		12 00	2 00
A 4780	General Crop Grower	Saline	F.†	0 87	0 31	0 42	1 60	14 20	2 20	12 00	2 09
A 4910	General Crop Grower	Plainwell		0 88	0 29	0 30	1 47	15 60	2 14	13 16	2 02
		Average		0 88	0 30	0.36	1 53	14 90	2 32	12 58	2.01
			G.†				1 60	9 00		8 00	10.00
A 4773	High Grade Complete	Saline	F.†	0 79	0 40	0 41	1 60	9 70	1 52	8 18	10 10
A 5211	High Grade Complete	Milan		0 87	0 39	0 30	1 56	9 45	1 54	7 91	9.64
		Average		0 83	0 40	0 35	1 58	9 58	1 53	8 05	9 87
			G.†				1 60	11 00		10 00	4 05
A 4783	Michigan Special	Saline	F.†	0 81	0 34	0 31	1 46	12 80	2 39	10 41	4 24
A 4907	Michigan Special	Allegan		0 94	0 38	0 28	1 40	12 90	2 72	10 18	3 72
		Average		0 87	0 36	0 30	1 53	12 85	2 55	10 30	3.98
			G.†				0 80	9 00		8 00	1 00
A 4782	One-Eight-One	Saline	F.†	0 41	0 18	0 21	0 80	9 60	1 76	7 84	1 46
A 4911	One-Eight-One	Plainwell		0 48	0 15	0 17	0 80	10 30	2 10	8 20	1 02
		Average		0 44	0 17	0 19	0 80	9 95	1 93	8 02	1 24
			G.†				2 50	9 00		8 00	6 00
A 4786	Special for Truck	Saline	F.†	1 36	0 43	0 15	2 24	9 45	1 34	8 11	5 52
A 4906	Special for Truck	Allegan		1 24	0 47	0 39	2 10	11 40	1 28	10 12	4 49
		Average		1 30	0 45	0 42	2 17	10 13	1 31	9 12	5 01
	Twelve-Two	....	G.†	...				...	...	12 00	2 00
	Morris & Company, Chicago, Ill.										
			G.†		...			17 00		16 00	....
A 4955	Big Brand 16% Acid Phosphate	Buchanan	F.†			...		18 00	0 22	17 88	....
	Natural Guano Co., Aurora, Ill.										
	"Sheep's Head" Pulverized Sheep Manure	....	G.†	...			2 25			1 00	1.50
	Nitrate Agencies Co., Columbus, Ohio										
	Nitrate of Soda	....	G.†	...			15 00		.	....	....
	Northern Fertilizer Co., Bay City, Mich.										
			G.†	....	...	....	0 82	.	...	12 00	1.50
A 5447	Choice	Reese	F.†	0 30	0 26	0 48	1 04	13 10	0 86	12 24	1.51
	Pacific Manure & Fertilizer Co., San Francisco, Cal.										
			G.†	....	....	...	1 84	1 25	...	0 75	3 00
A 4829	Groz-It Brand Pulverized Sheep Manure	Grand Rapids	F.†	1 94	0 05	0 10	2 09	1 20	0 16	1 04	2 99

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen.				Phosphoric acid.			Potash.
				As soluble.	As active insoluble organic.	As inactive insoluble organic.	Total.	Total.	Insoluble.	Available.	Water soluble.
	The Packers Fertilizer Co., Sandusky, Ohio										
			G.†	....	....	....	....	*17.00*	....	*16.00*	....
A 4699	Acid Phosphate........	Millington........	F.†	....	....	....	....	17.55	0.72	16.83	....
A 4994	Acid Phosphate........	Ruth........		....	....	....	....	18 90	0.90	18.00	....
		Average........		....	....	....	....	18 23	0.81	17.42	....
	Alkaline Phosphate........	....	*G.*†	....	....	....	....	....	....	*10.00*	*2.00*
	Big Bonanza........	....	*G.*†	....	....	....	*0.82*	....	....	*8.00*	*4.00*
	Bone Meal........	....	*G.*†	....	....	....	*1.65*	*17.00*	....	....	....
	Bone Meal & Acid Phosphate........	....	*G.*†	....	....	....	*1.25*	....	....	*10.00*	....
	Clay Soil Special........	....	*G.*†	....	....	....	*1.65*	....	....	*12.00*	....
			G.†	....	....	....	....	*15.00*	....	*14.00*	....
A 5474	Dissolved Phosphate........	Owosso........	F.†	....	....	....	....	11.15	1.48	**10.67**	....
			G.†	....	....	....	*0.82*	*11.00*	....	*10.00*	....
A 5473	Favorite Grain Grower........	Owosso........	F.†	0 80	0 06	0.07	0.93	11.55	1.18	10.37	....
			G.†	....	....	....	*0.41*	*11.00*	....	*10.00*	*1.00*
A 4698	O. K. Fertilizer........	Millington........	F.†	0 31	0 09	0 08	0.48	11.65	1.18	10.47	**0.86**
A 4992	O. K. Fertilizer........	Ruth........		0 48	0 08	0.12	0.68	12.45	1.20	11.25	1.01
		Average........		0.40	0.08	0.10	0 58	12.05	1.19	10.86	0.94
	Phosphate with Humus........	....	*G.*†	....	....	....	*0.41*	....	....	*12.00*	....
			G.†	....	....	....	*0.82*	*9.00*	....	*8.00*	*2.00*
A 4993	Potato and Tobacco Grower........	Ruth........	F.†	0.66	0.05	0 12	0.83	9.40	1.10	8.30	2.04
			G.†	....	....	....	*1.65*	*13.00*	....	*12.00*	*2.00*
A 4991	Quality Brand........	Harbor Beach........	F.†	1 44	0 13	0 16	1.73	13 88	2.04	11.84	2.27
A 5460	Quality Brand........	Saline........		1.72	0.14	0 13	1.99	14 00	2.48	**11.52**	2.02
		Average........		1.58	0.13	0 15	1.86	13 94	2 26	**11.68**	2.15

	Super Phosphate and Potash		G.†							10.00	4.90
	Sweepstakes		G.†				0.82			11.00	1.00
	Parke Davis & Co., Detroit, Mich.										
			G.†				7.67	6.45		5.00	1.47
A 5464	Parkedale	Detroit	F.†	0.99	4.44	2.29	7.72	6.98	2.58	4.40	0.39
	Poultry Feed Co., Chicago, Ill.										
			G.†				4.10	2.70		1.70	1.30
A 4936	Premier Pulverized Poultry Manure	Hudsonville	F.†	2.55	1.02	1.39	4.96	2.55	0.12	2.43	1.54
	The Pulverized Manure Co., Chicago, Ill.										
			G.†				1.80	1.00		1.00	1.00
A 4935	Wizard Brand Cattle Manure	Zeeland	F.†	0.04	0.46	1.30	1.80	1.23	0.10	1.13	2.01
	Wizard Brand Hog Manure		G.†				1.80			1.00	1.00
	Wizard Brand Mixed Manure		G.†				1.80			1.00	1.00
			G.†				1.80	1.00		1.00	1.00
A 5463	Wizard Brand Sheep Manure	Pontiac	F.†	0.32	0.47	1.27	2.06	1.15	0.18	0.97	2.13
	The Queen City Fertilizer Co., Cincinnati, Ohio										
			G.†				0.82	9.00		8.00	2.00
A 5402	Special Sugar Beet Grower	Erie City	F.†	0.74	0.11	0.10	0.95	9.85	1.32	8.53	2.06
	Rasin-Monumental Company, Cincinnati, Ohio										
			G.†					17.50		16.00	
A 5398	Rasin's 16% Acid Phosphate	Baldwin	F.†					17.80	0.46	17.34	
	Read Phosphate Co., New Albany, Ind.										
			G.†					9.00		8.00	10.00
A 4788	Blackland Special	Ypsilanti	F.†					9.30	0.62	8.68	9.54
A 4820	Blackland Special	Grand Rapids						9.50	0.16	9.34	9.20
A 4871	Blackland Special	Bangor						8.55	0.18	8.37	10.19
A 4904	Blackland Special	Hamilton						11.00	0.86	10.14	6.68
		Average						9.59	0.46	9.13	8.90
			G.†					17.00		16.00	
A 4195	Bureau Acid Phosphate	Zeeland	F.†					17.30	1.11	16.19	
A 4761	Bureau Acid Phosphate	Grand Blanc						18.60	2.38	16.22	
A 4822	Bureau Acid Phosphate	Grand Rapids						16.85	0.16	16.69	
A 4909	Bureau Acid Phosphate	Allegan						18.80	0.32	18.48	
		Average						17.89	0.99	16.90	

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	Read Phosphate Co.—Cont.										
			G.†	......	......	......	*1.60*	*13.00*	......	*12.00*	......
A 4193	Clayland Special	Zeeland	F.†	0.69	0.55	0.35	1.59	12.95	1.00	11.95	......
A 4821	Clayland Special	Grand Rapids		0.62	0.65	0.50	1.77	13.40	0.80	12.60	......
A 5220	Clayland Special	Dundee		0.63	0.83	0.38	1.84	14.20	2.20	12.00	......
A 5244	Clayland Special	Novi		0.60	0.57	0.54	1.71	13.65	1.68	11.97	......
		Average		0.64	0.65	0.44	1.73	13.55	1.42	12.13	......
			G.†	......	......	......	*1.60*	*13.00*	......	*12.00*	*2.00*
A 4787	General Crop Grower	Ypsilanti	F.†	0.84	0.45	0.41	1.70	13.90	0.46	13.44	2.01
A 4818	General Crop Grower	Grand Rapids		0.59	0.52	0.52	1.63	13.55	1.34	12.21	1.92
A 4968	General Crop Grower	Lake Odessa		0.98	0.40	0.29	1.67	15.50	2.04	13.46	1.81
A 5221	General Crop Grower	Dundee		0.32	1.09	0.57	1.98	15.70	4.52	11.18	1.78
A 5255	General Crop Grower	Monroe		1.52	0.09	0.15	1.76	14.50	2.60	11.90	2.16
		Average		0.85	0.51	0.39	1.75	14.63	2.19	12.44	1.94
			G.†	......	......	......	*1.60*	*11.00*	......	*10.00*	*4.00*
A 4870	Michigan Special	Bangor	F.†	1.19	0.32	0.44	1.95	11.87	1.98	9.89	5.04
A 4967	Michigan Special	Lake Odessa		1.03	0.45	0.29	1.77	13.15	2.74	10.41	4.07
		Average		1.11	0.38	0.37	1.86	12.51	2.36	10.15	4.56
			G.†	......	......	......	......	......	......	......	*48.00*
A 4872	Muriate of Potash	Bangor	F.†	......	......	......	......	......	......	......	51.61
			G.†	......	......	......	*14.75*	......	......	......	......
A 4790	Nitrate of Soda	Ypsilanti	F.†	......	......	......	14.91	......	......	......	......
			G.†	......	......	......	*0.80*	*9.00*	......	*8.00*	*1.00*
A 4903	One-Eight-One	Zeeland	F.†	0.35	0.21	0.34	0.90	14.70	5.60	9.10	0.84
			G.†	......	......	......	*2.46*	*9.00*	......	*8.00*	*6.00*
A 4819	Special Truck	Grand Rapids	F.†	1.55	0.47	0.46	2.48	9.10	1.10	8.00	6.68
A 5254	Special Truck	Monroe		1.71	0.49	0.44	2.64	9.25	1.30	7.95	6.22
		Average		1.63	0.48	0.45	2.56	9.18	1.20	7.98	6.45
			G.†	......	......	......	*20.50*	......	......	......	......
A 4789	Sulphate of Ammonia	Ypsilanti	F.†	......	......	......	21.14	......	......	......	......

			G.†					13 00		12 00	2 00
A 4194	Twelve-Two	Zeeland	F.†					12 70	0 52	12 18	1 63
A 4762	Twelve-Two	Grand Blanc						16 80	5 42	11 38	1 64
A 4931	Twelve-Two	Brunswick						17 20	4 34	12 86	1 64
A 5219	Twleve-Two	Dundee						12 35	0 36	11 99	1 73
A 5243	Twleve-Two	Novi						12 65	0 68	11 97	1 61
A 5386	Twelve-Two	Washington						14 00	0 28	13 72	1 39
		Average						14 28	1 93	12 35	1 61
	F. S. Royster Guano Co., Toldeo, Ohio										
	Nitrate of Soda		G.†				15 00				
			G.†					16 50		16 00	
A 4705	16% Acid Phosphate	Quincy	F.†					17 60	0 60	17 00	
A 4733	16% Acid Phosphate	Tecumseh						17 30	0 98	16 32	
A 4814	16% Acid Phosphate	Coopersville						17 65	1 36	16 29	
		Average						17 52	0 98	16 54	
	Black Soil Guano		G.†				0 80			8 00	5 00
			G.†				0 80	8 50		8 00	1 00
A 4817	Cuckoo Guano	Coopersville	F.†	0 39	0 28	0 16	0 83	11 10	0 86	10 21	1 13
A 5216	Cuckoo Guano	Azalia		0 68	0 29	0 20	1 17	10 95	1 24	9 71	2 01
		Average		0.53	0 29	0 18	1 00	11 03	1 05	9 98	1 57
			G.†				1 60	10 50		10 00	4 00
A 5042	Excello Guano	Belding	F.†	1 01	0 28	0 31	1 60	11 70	1 60	10 10	4 26
			G.†				1 60	8 50		8 00	3 00
A 5215	Fish, Flesh & Fowl	Azalia	F.†	1 01	0 10	0 25	1.66	9 75	1 50	8 25	3 10
			G.†				1 60	12 50		12 00	
A 4932	Security Brand	Fremont	F.†	0 91	0 59	0 18	1 71	15 00	1 80	13 20	
A 5245	Security Brand	Plymouth		1 05	0 55	0 25	1 85	14 00	1 84	12 16	
		Average		1 00	0 57	0 21	1 78	14 50	1 82	12 68	
			G.†				0 80	11 50		11 00	2 00
A 4740	Special Fish Guano	Tecumseh	F.†	0 64	0 13	0 09	0 86	13 45	1 60	11 85	2 13
A 4816	Special Fish Guano	Coopersville		0 47	0 15	0.17	0 79	13 55	1 52	12 03	2.15
A 4999	Special Fish Guano	Cass City		0 54	0 14	0 20	0 88	13 15	1 54	12 61	2 06
A 5217	Special Fish Guano	Azalia		0 57	0 15	0 14	0 86	13 55	1 52	12 03	2 06
		Average		0 56	0 14	0 15	0 85	13 68	1 55	12 13	2 10

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at	Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	F. S. Royster Guano Co.—Cont.									
		G.†	......	......	......	*1.60*	*8.50*	......	*8.00*	*8.00*
A 4736	Trump Guano	Tecumseh F.†	1.05	0.37	0.21	1.63	10.20	1.38	8.82	7.57
A 4812	Trump Guano	Coopersville	0.75	0.38	0.29	1.42	10.55	1.40	9.15	8.01
A 4893	Trump Guano	Decatur	0.97	0.32	0.30	1.59	9.90	1.14	8.76	7.50
A 5263	Trump Guano	Monroe	1.12	0.27	0.24	1.63	10.35	1.22	9.13	7.75
		Average	0.97	0.34	0.26	1.57	10.25	1.29	8.96	7.71
		G.†	......	......	......	*1.60*	*12.50*	......	*12.00*	*2.00*
A 4735	Vim Guano	Tecumseh F.†	1.02	0.27	0.19	1.48	13.75	1.18	12.57	2.84
A 4815	Vim Guano	Coopersville	1.05	0.47	0.26	1.78	13.95	1.94	12.01	2.29
A 5246	Vim Guano	Plymouth	0.92	0.51	0.25	1.68	13.45	1.72	11.73	2.80
		Average	1.00	0.42	0.23	1.65	13.72	1.61	12.11	2.64
		G.†	......	......	......	*0.80*	*8.50*	......	*8.00*	*3.00*
A 4734	Wonder Guano	Tecumseh F.†	0.43	0.22	0.15	0.80	10.65	1.24	9.41	3.50
A 4983	Wonder Guano	Shepard	0.63	0.22	0.13	0.98	10.55	0.98	9.57	2.94
A 5262	Wonder Guano	Monroe	0.75	0.21	0.21	1.17	10.95	1.36	9.59	3.00
		Average	0.60	0.22	0.16	0.98	10.72	1.19	9.53	3.15
		G.†	......	......	......	*1.60*	*8.50*	......	*8.00*	*15.00*
A 4706	2-8-15	Quincy F.†	1.01	0.37	0.22	1.60	10.00	1.26	8.61	16.88
A 4850	2-8-15	Pearl	1.06	0.28	0.23	1.57	10.00	1.44	8.56	15.78
A 4851	2-8-15	Pearl	1.04	0.30	0.22	1.56	10.15	1.48	8.67	15.13
A 4852	2-8-15	Pearl	1.09	0.28	0.20	1.57	9.85	1.30	8.55	16.37
A 4853	2-8-15	Mentha	1.03	0.30	0.23	1.56	10.00	1.38	8.62	15.27
A 4854	2-8-15	Mentha	1.06	0.30	0.28	1.64	9.95	1.42	8.53	15.81
A 4856	2-8-15	Mentha	1.13	0.31	0.24	1.68	10.00	1.38	8.62	15.25
A 4857	2-8-15	Mentha	1.18	0.26	0.26	1.70	9.90	1.54	8.36	16.56
A 4858	2-8-15	Mentha	1.10	0.33	0.27	1.70	9.90	1.30	8.60	15.41
A 5252	2-8-15	Plymouth	0.97	0.37	0.40	1.74	10.15	1.36	8.79	15.40
		Average	1.07	0.31	0.26	1.64	9.99	1.40	8.59	15.79
		G.†	......	......	......	......	*10.50*	......	*10.00*	*2.00*
A 4990	10-2 Phosphate & Potash	Owendale F.†	......	......	......	......	12.75	0.86	11.89	2.17

A 4916	10-8 Phosphate & Potash	Portage	G.†					*10.50*		*10.00*	*8.00*
			F.†					13.40	1.58	11.82	9.25
A 4737	10-10 Phosphate & Potash	Tecumseh	G.†					*10.50*		*10.00*	*10.00*
			F.†					12.25	1.46	10.79	10.17
A 4918	10-10 Phosphate & Potash	Portage						13.35	1.41	11.91	10.09
		Average						12.80	1.45	11.35	10.13
A 4739	12-2 Phosphate & Potash	Tecumseh	G.†					*12.50*		*12.00*	*2.00*
			F.†					14.50	1.12	13.38	2.41
A 5250	12-2 Phosphate & Potash	Plymouth						14.95	1.04	13.91	2.00
		Average						14.73	1.08	13.65	2.22
A 4738	12-4 Phosphate & Potash	Tecumseh	G.†					*12.50*		*12.00*	*4.00*
			F.†					14.35	1.12	13.23	3.79
A 4989	12-4 Phosphate & Potash	Owendale						14.60	0.98	13.62	4.50
A 5000	12-4 Phosphate & Potash	Cass City						14.70	1.10	13.60	4.18
		Average						11.55	1.07	13.48	4.16
A 4813	50-50 Bone & Phosphate	Coopersville	G.†				*1.23*	*20.00*		*13.00*	
			F.†	0.53	0.55	0.21	1.32	21.40	10.80	10.60	
	Smith Agricultural Chemical Co., Columbus, Ohio										
A 4828	16% Acid Phosphate	Nunica	G.†							*16.00*	
			F.†					16.45	0.52	15.93	
A 5267	16% Acid Phosphate	Maybee						16.70	0.36	16.34	
A 5374	16% Acid Phosphate	Almont						17.80	0.40	17.40	
		Average						16.98	0.42	16.56	
A 4827	Ammoniated Phosphate & Potash	Nunica	G.†				*0.80*			*8.00*	*1.00*
			F.†	0.55	0.13	0.16	0.84	10.05	0.56	9.49	1.16
A 5377	Ammoniated Phosphate & Potash	Almont		0.52	0.12	0.20	0.84	9.30	0.50	8.80	1.01
		Average		0.53	0.13	0.17	0.84	9.68	0.53	9.15	1.08
A 4825	Climax Phosphate	Nunica	G.†							*10.00*	*4.00*
			F.†					10.70	0.24	10.46	4.40
A 5373	Climax Phosphate	Almont						10.15	0.32	10.13	3.78
		Average						10.58	0.28	10.30	4.09
A 5376	Crop Producer	Almont	G.†				*1.60*			*12.00*	
			F.†	0.98	0.21	0.30	1.49	13.35	0.80	12.55	

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	Smith Agricultural Chemical Co.—Cont.										
	Grain Grower		G.†				*0.80*			*14.00*	*1.00*
	One Ten		G.†				*0.80*			*10.00*	
			G.†							*10.00*	*2.00*
A 5266	Phosphate & Potash	Maybee	F.†					10.80	0.42	10.38	2.02
A 5375	Phosphate & Potash	Almont						11.10	0.44	10.66	2.17
		Average						10.95	0.43	10.52	2.10
			G.†				*0.80*			*8.00*	*2.00*
A 5372	Potash Formula	Almont	F.†	0.51	0.12	0.25	0.88	9.15	0.60	8.55	2.02
A 4826	Potash Formula	Nunica		0.44	0.14	0.21	0.79	9.80	1.61	8.19	1.94
		Average		0.48	0.13	0.23	0.84	9.48	1.11	8.37	1.98
			G.†				*0.40*			*12.00*	
A 5378	Wheat Maker & Seeding Down	Almont	F.†	0.12	0.16	0.18	0.46	13.30	0.74	12.56	
	Elmer D. Smith Company, Adrian, Mich.										
			G.†				*16.00*			*24.00*	*20.00*
A 5237	Chrysaline	Adrian	F.†				16.88	24.80	0.00	24.80	20.85
	Sodus Humus Co. Inc. Harbor Beach Mich.										
	Sodus Humus		G.†				*1.29*				
	The J. L. & N. Stadler Rend. & Fert. Co., Cleveland, O.										
			G.†				*1.60*	*9.00*		*8.00*	*2.00*
A 5227	Grain Grower	Blissfield	F.†	0.76	0.26	0.54	1.56	8.85	1.10	7.75	2.27
A 5265	Grain Grower	Maybee		0.89	0.28	0.53	1.70	9.20	1.06	8.14	2.13
		Average		0.82	0.27	0.54	1.63	9.03	1.08	7.95	2.20
			G.†				*0.80*	*10.00*		*9.00*	*1.00*
A 5228	Harvest King	Blissfield	F.†	0.49	0.17	0.29	0.95	11.15	1.52	9.63	1.00

	R. Stewart & Sons, Battle Creek, Mich.											
			G.†	....	....	....	*4.50*	*15.00*	....	....	....	
A 8105	Tankage	Battle Creek	F.†	1.51	2.49	1.74	5.74	13.00	....	....	....	
	Swift & Co. Fert. Works, Hammond, Ind.											
			G.†	....	....	....	*1.65*	*13.00*	....	*12.00*	*2.00*	
A 4711	Champion Wheat & Corn Grower	Albion	F.†	1.39	0.17	0.10	1.66	13.50	0.66	12.84	2.69	
A 4745	Champion Wheat & Corn Grower	Ovid		1.37	0.24	....	1.61	12.90	0.44	12.46	1.78	
A 4953	Champion Wheat & Corn Grower	Berrien Springs		1.17	0.17	0.14	1.48	13.60	0.64	12.96	2.72	
A 5434	Champion Wheat & Corn Grower	Birch Run		1.44	0.17	0.12	1.73	13.80	0.62	13.18	2.21	
		Average		1.34	0.19	0.09	1.62	13.45	0.59	12.86	2.35	
			G.†	....	....	....	*1.65*	*13.00*	....	*12.00*	....	
A 4934	Clay Soil Special	Fremont	F.†	1.37	0.17	0.07	1.61	13.90	0.54	13.36	....	
A 4957	Clay Soil Special	Eau Claire		1.03	0.21	0.07	1.31	13.60	0.68	12.92	....	
A 5445	Clay Soil Special	Reese		1.32	0.18	0.14	1.64	13.95	0.74	13.21	....	
		Average		1.24	0.19	0.09	1.52	13.82	0.65	13.17	....	
			G.†	....	....	....	*0.82*	*8.50*	....	*8.00*	*1.00*	
A 4702	Complete Fertilizer	Mason	F.†	0.39	0.23	0.12	0.74	9.75	0.72	9.03	1.13	
A 4792	Complete Fertilizer	Ypsilanti		0.43	0.17	0.21	0.81	9.25	0.72	8.53	1.47	
A 4982	Complete Fertilizer	Shepard		0.53	0.18	0.19	0.90	9.80	0.84	8.96	1.05	
		Average		0.45	0.20	0.17	0.82	9.60	0.76	8.84	1.22	
			G.†	....	....	....	*0.82*	*12.50*	....	*12.00*	*1.00*	
A 4746	Diamond K Grain Grower	Ovid	F.†	0.63	0.18	0.03	0.84	13.00	0.92	12.08	1.05	
A 4869	Diamond K. Grain Grower	South Haven		0.66	0.21	0.01	0.88	14.00	1.44	12.56	1.02	
		Average		0.64	0.20	0.02	0.86	13.50	1.18	12.32	1.04	
			G.†	....	....	....	*2.46*	*11.00*	....	*10.00*	*4.00*	
A 4897	Fruit & Vegetable Grower	Decatur	F.†	1.99	0.21	0.08	2.28	10.30	0.20	10.10	4.64	
A 4930	Fruit & Vegetable Grower	Muskegon		1.54	0.22	0.17	1.93	11.60	0.36	11.24	4.14	
A 4956	Fruit & Vegetable Grower	Eau Claire		1.90	0.24	0.13	2.27	11.40	0.34	11.06	3.68	
A 5428	Fruit & Vegetable Grower	Clio		1.94	0.26	0.15	2.35	11.70	0.80	10.90	4.00	
		Average		1.85	0.23	0.13	2.21	11.25	0.42	10.83	4.12	
			G.†	....	....	....	....	....	....	*16.00*	....	
A 4795	High Grade Acid Phosphate Fert.	Denton	F.†	....	....	....	....	17.00	0.70	16.30	....	
A 4868	High Grade Acid Phosphate Fert.	South Haven		....	....	....	....	17.80	0.82	16.98	....	
A 4878	High Grade Phosphate Fert.	Coloma		....	....	....	....	17.65	0.72	16.93	....	
A 5240	High Grade Acid Phosphate Fert.	Howell		....	....	....	....	18.10	0.84	17.26	....	
		Average		....	....	....	....	17.64	0.77	16.87	....	

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	Swift & Co. Fert. Works—Cont.										
			G.†	....	....	....	*1.65*	*1.00*	....	....	*2.00*
A 4700	Pulverized Manure	Mason	F.†	0.07	0.54	1.24	1.85	1.10	....	....	2.02
A 4791	Pulverized Manure	Ypsilanti		0.24	0.35	0.91	**1.50**	2.00	....	....	2.04
A 4867	Pulverized Manure	South Haven		0.30	0.37	0.96	1.63	2.60	....	....	**1.63**
A 5277	Pulverized Manure	Lansing		0.18	0.43	1.27	1.88	1.10	....	....	2.01
		Average		0.20	0.42	1.10	1.72	1.70	....	....	1.93
			G.†	....	....	....	*0.82*	*12.50*	....	*12.00*	*3.00*
A 4701	Red Steer 1-13-2	Mason	F.†	0.46	0.22	0.13	0.81	13.35	1.18	12.17	3.32
A 4797	Red Steer 1-12-3	Denton		0.62	0.28	0.01	0.91	13.35	1.08	12.27	4.02
A 4952	Red Steer 1-12-3	Saranac		0.73	0.21	0.00	0.94	14.30	1.16	13.14	2.92
		Average		0.60	0.24	0.05	0.89	13.67	1.14	12.53	3.42
			G.†	....	....	....	*1.65*	*9.00*	....	*8.00*	*2.00*
A 5275	Red Steer 2-8-2	Lansing	F.†	1.13	0.23	0.21	1.57	11.85	0.58	11.27	**1.22**
A 5437	Red Steer 2-8-2	Reese		0.83	0.26	0.29	**1.38**	10.35	0.56	9.79	3.90
		Average		0.98	0.25	0.25	1.48	11.10	0.75	10.53	2.56
			G.†	....	....	....	*3.28*	*9.00*	....	*8.00*	*8.00*
A 4988	Red Steer 4-8-8	Essexville	F.†	2.72	0.17	0.12	**3.01**	8.75	0.22	8.53	**7.72**
			G.†	....	....	....	*0.82*	*12.50*	....	*12.00*	....
A 5452	Tankage & Bone Phosphate	Kingston	F.†	0.66	0.19	0.09	0.94	13.50	1.18	12.32	....
			G.†	....	....	....	*0.82*	*8.50*	....	*8.00*	*2.00*
A 5439	1-8-2 Fertilizer	Reese	F.†	0.65	0.20	0.22	1.07	10.15	0.60	9.55	2.06
			G.†	....	....	....	*0.82*	*8.50*	....	*8.00*	*3.00*
A 4896	1-8-3 Fertilizer	Decatur	F.†	0.41	0.15	0.23	0.79	9.40	0.86	8.54	**2.83**
A 5238	1-8-3 Fertilizer	Manchester		0.38	0.16	0.26	0.80	9.00	1.00	8.00	3.35
A 5334	1-8-3 Fertilizer	Corunna		0.54	0.16	0.18	0.88	9.35	0.36	8.99	3.49
A 5438	1-8-3 Fertilizer	Reese		0.53	0.17	0.18	0.88	10.35	0.58	9.77	**2.47**
		Average		0.47	0.16	0.21	0.84	9.53	0.70	8.83	3.04
			G.†	....	....	....	*0.82*	*8.50*	....	*8.00*	*6.00*
A 4796	1-8-6 Fertilizer	Denton	F.†	0.51	0.15	0.17	0.83	9.40	1.04	8.36	6.04
A 4866	1-8-6 Fertilizer	South Haven		0.47	0.15	0.19	0.81	10.00	0.94	9.06	**4.32**

A 4898	1-8-6 Fertilizer	Decatur		0.37	0.15	0.27	0.79	10.10	1.52	8.58	**5.12**
A 4954	1-8-6 Fertilizer	Berrien Springs		0.46	0.13	0.12	0.71	1.10	0.44	**7.66**	**5.53**
A 5241	1-8-6 Fertilizer	Brighton		0.51	0.14	0.15	0.80	9.90	0.74	9.16	6.88
		Average		0.46	0.14	0.18	0.78	9.50	0.94	8.56	**5.58**
			G.†	...	...	...	*1.65*	*9.00*	...	*8.00*	*15.00*
A 4895	2-8-15 Fertilizer	Decatur	F.†	1.49	0.14	0.07	1.70	8.35	0.30	8.05	15.70
			G.†	...	...	...	*1.86*	*29.00*	...	...	...
A 4703	2 1/4-29 Bone Meal	Mason	F.†	0.41	1.16	0.45	2.02	28.90	...	...	...
A 4919	2 1/4-29 Bone Meal	Portage		0.32	1.14	0.57	2.03	30.40	...	...	...
A 5278	2 1/4-29 Bone Meal	Lansing		0.33	0.99	0.53	1.85	30.70	...	...	...
A 5430	2 1/4-29 Bone Meal	Clio		0.08	0.96	0.67	**1.71**	30.80	...	...	...
		Average		0.28	1.06	0.56	1.90	30.20	...	...	...
			G.†	...	...	...	...	*10.50*	...	*10.00*	*4.00*
A 5444	10-4 Fertilizer	Reese	F.†	...	...	...	...	10.80	0.30	10.50	4.92
			G.†	...	...	...	...	*10.50*	...	*10.00*	*10.00*
A 5276	10-10 Fertilizer	Lansing	F.†	...	...	...	...	11.05	0.30	10.75	10.54
A 5446	10-10 Fertilizer	Reese		...	...	...	...	11.20	0.40	10.80	**6.51**
		Average		...	...	...	...	11.13	0.35	10.78	**8.53**
			G.†	...	...	...	...	*12.50*	...	*12.00*	*2.00*
A 4798	12-2 Fertilizer	Denton	F.†	...	...	...	...	13.08	0.58	12.50	2.18
A 4951	12-2 Fertilizer	Saranac		...	...	...	...	13.70	0.74	12.96	2.02
A 5239	12-2 Fertilizer	Manchester		...	...	...	...	12.95	0.98	11.97	2.97
A 5429	12-2 Fertilizer	Clio		...	...	...	...	13.70	0.94	12.76	2.18
		Average		...	...	...	...	13.36	0.81	12.55	2.34
	Virginia-Carolina Chemical Co., Cincinnati, Ohio										
			G.†	...	...	...	...	*15.50*	...	*10.00*	*4.00*
A 5469	V-C Acid and Potash King	Tecumseh	F.†	...	...	...	...	13.30	2.32	10.98	4.38
			G.†	...	...	...	...	*17.50*	...	*16.00*	...
A 5261	V-C 16% Acid Phosphate	Erie	F.†	...	...	...	...	17.10	0.26	16.84	...
A 5273	V-C 16% Acid Phosphate	Pittsford		...	...	...	...	17.30	0.30	17.00	...
		Average		...	...	...	...	17.20	0.28	16.92	...
			G.†	...	...	...	...	*21.50*	...	*20.00*	...
A 4811	V-C 20% Acid Phosphate	Coopersville	F.†	...	...	...	...	21.60	0.30	21.30	...
A 4823	V-C 20% Acid Phosphate	Grand Rapids		...	...	...	...	22.00	0.38	21.62	...
A 5212	V-C 20% Acid Phosphate	Milan		...	...	...	...	21.30	0.66	20.64	...
		Average		...	...	...	...	21.63	0.45	21.18	...

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	Virginia-Carolina Co.,—Cont.										
			G.†				*2 47*	*11 50*		*10 00*	*4 00*
A 4933	V-C Big Potato & Truck	Fremont	F.†	1 64	0 31	0 36	2 31	12 30	0 56	11 74	4 69
A 5260	V-C Big Potato & Truck	Erie		1 45	0 39	0 47	2 31	10.70	0 46	10.21	4 24
A 5279	V-C Potato & Truck	Lansing		1 61	0 38	0 45	2 44	11 10	0 42	10 68	4 27
A 5471	V-C Big Potato & Truck	Tecumseh		1 73	0 30	0 43	2 46	11 60	0 41	11 16	4.44
		Average		1.61	0.35	0 42	2 38	11.43	0.47	10 96	4.41
			G.†				*0 82*	*22 00*		*10 00*	
A 5040	V-C Bone Meal & Phosphate	Paw Paw	F.†	0 31	0 55	0 21	1.10	23.60	12.32	11.28	
			G.†				*0.82*	*9.50*		*8 00*	*2.00*
A 5020	V-C Champion Corn & Wheat Grower	Amble	F.†	0 64	0 22	0 15	1 01	9 20	0.31	8.66	2.00
			G.†				*1 65*	*9.50*		*8 00*	*2.00*
A 5472	V-C Complete Fertilizer	Lenawee Junction	F.†	1.39	0 27	0 28	1.91	10.50	0 78	9.72	2.16
			G.†				*0 82*	*9.50*		*8 00*	*1.00*
A 5291	V-C Complete Manure	Holly	F.†	0 64	0 22	0 07	0 93	9.80	0 32	9.48	1.25
			G.†					*11.50*		*10 00*	*8.00*
A 5292	V-C Monarch Acid & Potash Compound	Holly	F.†					11 65	0 98	10 67	8 04
A 5170	V-C Monarch Acid & Potash Compound	Tecumseh						12 65	2.18	10 47	7.47
		Average						12 15	1.58	10 57	7 76
			G.†								*48.00*
A 5281	V-C Muriate of Potash	Lansing	F.†								50.71
			G.†				*4 92*	*9.50*		*8 00*	*3.00*
A 5282	V-C Plant Food for Vegetables, Lawns and Flowers	Lansing	F.†	4.98	0.52	0 60	6.10	11.75	2.12	9 63	3.65
			G.†				*1 65*	*11.50*		*10 00*	*8 00*
A 4775	V-C Pride of the North	Ann Arbor	F.†	1.47	0 29	0.30	2.06	11.45	0.86	10.59	8.37
	V-C Prolific Grain Grower		*G.*†							*12.00*	*2.00*
			G.†				*1.65*	*2.50*		*11.00*	
A 4905	V-C Rescue Fertilizer	Allegan	F.†	1.02	0.42	0.34	1.78	13.45	0.90	12.55	

			G.†				*1 65*	*13 50*		*12.00*	*2.00*
A 4774	V-C Springfall Fertilizer	Ann Arbor	F.†	1 54	0 11	0 09	1.74	13 10	0 30	12 80	2.24
A 5274	V-C Springfall Fertilizer	Pittsford		1.59	0 12	0 09	1.80	13 40	0 20	13 20	2.56
		Average		1.56	0 12	0.09	1.77	13 25	0.25	13 00	2.40
			G.†				*2 47*	*22 00*			
A 5280	V-C Steamed Bone	Lansing	F.†	0 51	1 27	0 61	2.41	23 30			
			G.†				*0.82*	*14 50*		*13 00*	
A 5401	V-C Sure Grain Producer	Jasper	F.†	0 52	0 26	0 02	0.80	15.85	0 32	15.53	
	The Wayne Soap Company, Detroit, Mich.										
	Fertilo		G.†				*2 70*			*16.50*	
	The Welch Chemical Co., Columbus, Ohio										
			G.†				*0 82*			*11 00*	*3 00*
A 4769	No. 1—Independent Favorite	Swartz Creek	F.†	0 33	0 17	0 27	0 77	11 50	0 38	11 12	3 32
A 5457	No. 1—Independent Favorite	Saline		0 40	0 15	0 26	0 81	12 25	0 34	11.91	3 03
		Average		0 36	0 16	0 27	0 79	11 88	0 36	11 52	3 13
			G.†				*0 82*	*16 00*		*8 00*	*1 00*
A 4770	No. 2—Independent Bone Meal & Phosphate Mixture	Swartz Creek	F.†	0 39	0 18	0 27	0 81	16 55	9 05	7 50	1 26
A 5458	No. 2—Independent Bone Meal & Phosphate Mixture	Saline		0 30	0 18	0 26	0 74	15 50	6 42	9 08	0 91
		Average		0 34	0 18	0 27	0 79	16 03	7 74	8 29	1 09
			G.†				*0 41*			*8 00*	*1 03*
A 4771	No. 3—Independent Corn, Wheat, Oats & Clover	Swartz Creek	F.†	0 14	0 08	0 19	0 41	9 25	0 98	8 27	1 03
A 4969	No. 3—Independent Corn, Wheat, Oats & Clover	Elmdale		0 13	0 08	0 23	0 41	9 45	0 76	8 69	1 01
A 5355	No. 3—Independent Corn, Wheat, Oats & Clover	Lapeer		0 15	0 09	0 25	0 49	9 20	0 82	8 38	1 09
		Average		0 14	0 08	0 22	0 44	9 30	0 85	8 45	1 05
			G.†				*0 82*			*8 00*	*4 00*
A 4998	No. 4—Independent Grain Special	Cass City	F.†	0 63	0 08	0 12	0 83	8 20	0 68	7 52	4 03
A 5419	No. 4—Independent Grain Special	Richmond		0 61	0 08	0 19	0 88	9 15	1 16	8 28	4 28
A 5432	No. 4—Independent Grain Special	Clio		0 70	0 07	0 17	0 94	9 30	0.76	8 54	4 10
		Average		0 64	0 08	0 16	0 88	8 98	0 87	8 11	4 14
			G.†				*1 65*			*12 00*	
A 5476	No. 5—Independent Universal Crop	Merrill	F.†	1.41	0 31	0 32	2 04	13 10	0.78	12 32	
			G.†				*1 65*			*12 00*	*2.00*
A 5177	No. 6—Independent High Grade General Crop	Merrill	F.†	1 08	0 29	0 23	1 60	13.50	1 08	12 42	2.30
			G.†				*0 82*			*8 00*	*2 00*
A 4970	No. 7—Independent Corn & Wheat Special	Elmdale	F.†	0 73	0 11	0 13	0 97	9 45	0.76	8.69	2 00
	No. 8—Independent Potash Mixture		G.†							*10 00*	*2.00*

†Abbreviations for guaranteed and found.

ANALYSES OF COMMERCIAL FERTILIZER FOR SPRING SEASON OF 1921 EXPRESSED IN PARTS IN ONE HUNDRED.—Continued.

Laboratory No.	Manufacturer and trade name.	Sampled at		Nitrogen. As soluble.	Nitrogen. As active insoluble organic.	Nitrogen. As inactive insoluble organic.	Nitrogen. Total.	Phosphoric acid. Total.	Phosphoric acid. Insoluble.	Phosphoric acid. Available.	Potash. Water soluble.
	The Welsh Chemical Company—Cont.										
			G.†	....	....	....	*0.41*	....	....	*12.00*	....
A 5356	No. 9—Independent Ammoniated Phosphate	Lapeer	F.†	0.07	0.08	0.17	0.32	13.10	1.49	11.61	....
			G.†	....	....	....	....	....	....	*16.00*	....
A 4768	No. 11—Independent High Grade Phosphate	Swartz Creek	F.†	....	....	....	....	17.80	0.34	17.46	....
A 4980	No. 11—Independent High Grade Phosphate	Ithaca		....	....	....	....	18.60	0.38	18.22	....
		Average		....	....	....	....	18.20	0.36	17.84	....
			G.†	....	....	....	....	....	....	*10.00*	*8.00*
A 4981	Independent Potash Compound	Ithaca	F.†	....	....	....	....	11.40	0.48	10.92	6.48
A 5433	Independent Potash Compound	Clio		....	....	....	....	10.45	0.44	10.01	8.07
		Average		....	....	....	....	10.93	0.46	10.47	7.28
			G.†	....	....	....	*0.82*	....	....	*8.00*	*2.00*
A 4772	Independent Sugar Beet Special	Swartz Creek	F.†	0.63	0.09	0.11	0.83	8.65	0.74	7.91	2.01
A 4979	Independent Sugar Beet Special	Ithaca		0.69	0.11	0.11	0.91	8.63	0.64	7.99	1.64
		Average		0.66	0.10	0.11	0.87	8.64	0.69	7.95	1.83
	Wing & Evans, Inc. Detroit,, Mich.										
	"U-S" Potash		*G.*†	....	....	....	....	....	....	....	*52.00*
	The Wuichet Fertilizer Co., Dayton, Ohio										
			G.†	....	....	....	*0.40*	*9.00*	....	*8.00*	*3.00*
A 4697	EE Gem Fertilizer	Owosso	F.†	0.16	0.11	0.11	0.38	8.20	0.56	7.64	3.69
A 4753	EE Gem Fertilizer	Ovid		0.19	0.11	0.14	0.44	8.85	0.50	8.35	3.00
A 4757	EE Gem Fertilizer	Lennon		0.20	0.11	0.13	0.44	8.15	0.46	7.69	2.77
		Average		0.18	0.11	0.13	0.42	8.40	0.51	7.89	3.15
			G.†	....	....	....	*1.60*	*14.00*	....	*8.00*	....
A 4720	EE Raw Bone Phosphate	Hillsdale	F.†	0.66	0.67	0.51	1.84	11.73	3.74	7.99	....

			G.†	....	....	....	*0.40*	*12.00*	....	*11.00*	....
A 4696	EE Ruby Fertilizer	Owosso	F.†	0.07	0.16	0.11	0.34	11.48	0.74	10.74	....
A 4721	EE Ruby Fertilizer	Hillsdale		0.13	0.17	0.15	0.45	12.10	0.86	11.24	....
A 4755	EE Ruby Fertilizer	Ovid		0.12	0.17	0.12	0.41	11.70	0.80	10.90	....
		Average		0.10	0.17	0.13	0.10	11.76	0.80	10.96	....
			G.†	....	....	....	*0.80*	*9.00*	....	*8.00*	*2.00*
A 4754	EE Spot Cash Special	Ovid	F.†	0.31	0.21	0.25	0.80	9.95	2.11	7.83	2.17
A 4756	EE Spot Cash Special	Henderson		0.38	0.20	0.28	0.86	9.85	1.92	7.93	2.15
		Average		0.36	0.20	0.27	0.83	9.90	2.02	7.88	2.16
			G.†	....	....	....	*1.60*	*9.00*	....	*8.00*	*8.00*
A 4722	Onion & Truck Fertilizer	Hillsdale	F.†	0.87	0.27	0.36	1.50	9.55	1.12	8.43	9.57
			G.†	....	....	....	....	*17.00*	....	*16.00*	....
A 4723	16% Phosphate	Hillsdale	F.†	....	....	....	....	15.50	0.20	15.30	....

†Abbreviation for guaranteed and found.

ROSEN RYE

Special Bulletin No. 105

FRANK A. SPRAGG, FARM CROPS SECTION

In 1909, the Michigan Agricultural Experiment Station received a sample of pedigreed rye from Russia, through Mr. J. A. Rosen, a Russian student who graduated from the Agricultural College in 1908. Since the Russian name of this rye was unknown it was named Rosen rye. Figure No. 1 shows the first piece of Rosen rye planted in Michigan, fall 1909.

TESTING.

This sample was tested by the Michigan Experiment Station. As this rye showed its superiority, it was only necessary to establish this fact in the mind of the experimenter before distribution. Most of the early dis-

Figure No. 1. The plat shown in the center of the cut is the original or first planting of Rosen rye in Michigan. The seed received from Russia was planted by the side of the alfalfa nursery in the fall of 1909. The picture was taken in the spring of 1910.

tributions were lost to pedigree by being planted along side of common varieties.

A bushel distributed in 1912 was placed in the hands of a Jackson county farmer, a member of the Michigan Crop Improvement Association, who planted it away from other rye, on an acre of ground. This yielded thirty-five bushels in 1913. Soon the whole country-side around Parma in western Jackson county, and around Albion in eastern Calhoun county grew Rosen rye as a winter crop, and little or no wheat. Other counties took it up and with the aid of the Michigan Crop Improvement Association and active county agricultural agents, the new rye spread rapidly. In 1917, St. Joseph county had 3,500 acres, Jackson county had 2,000 acres, and the whole state of Michigan, about 15,000 acres. Thus it took four more years for the new variety to attract the notice and confidence necessary to create a demand for pedigreed seed. In 1920, Michigan for the first time exceeded any other state in the Union in rye production. Without doubt the extensive planting of Rosen rye has had much to do in placing the state first in rye growing.

RYE OPEN FERTILE.

Rye is naturally a wind pollinated plant. The head contains four rows of flowers in groups of twos, on alternate sides of the flat end of the stem, called the rachis. Each of these flowers contains a one seeded ovary and three very large anthers. The anthers open at the end and shatter the pollen out into the air. This is normally done without allowing any of the pollen

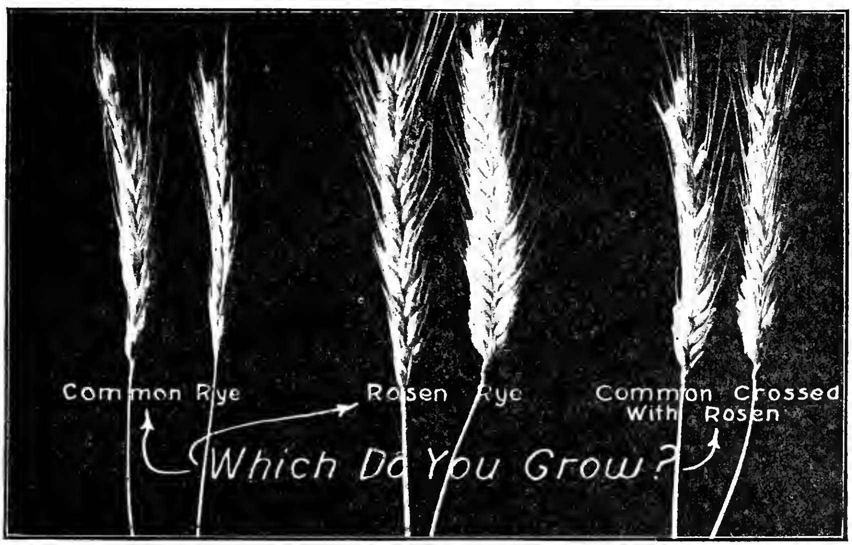


Figure No. 2. The two heads in the center are Rosen rye. Common rye is shown at the left and a cross between common and Rosen at the right. In each case a side and an edge view is shown. Note the good filling of the Rosen in comparison with the common crossed rye.

to fall back into the flower. Thus it happens that the flowers are normally cross pollinated. It is the pollen that is blown over from another plant that enters the flower and fertilizes the ovule.

For this reason it happens that many flowers fail to be pollinated. Their own pollen is shoved out and blown away, the flowers are not open long enough to catch other pollen, or the small quantity of pollen, that enters,

fails to develop in such a manner as to fertilize the ovule. This is an important matter as production depends upon the fertilization of the ovules. Many of the common ryes fail to fertilize more than half of the ovules, making an irregular poorly filled head. It is altogether different in wheat where the pollen is shattered inside the flowers and there is, therefore, an abundance for self-fertilization.

Michigan rye varieties may be classified as common, Rosen, and the crosses between these two types. The ryes that were commonly grown before the Rosen rye was introduced are referred to as the common varieties. Figure 2 shows the Rosen in the center, the common at the left and a frequent type of crossed rye at the right. Here one may see the large grains of the Rosen combined with the poor filling of the common rye.

At first the Rosen rye frequently yielded twice as much as the common. As the ryes were commonly planted side by side, they were inter-crossed, yielding grade ryes, ranging all the way from nearly pure Rosen to nearly pure common. Gradually the poorest producing seed has been eliminated, and now it is likely that about 85 per cent of the rye grown in Michigan is at least grade Rosen.

TRUENESS TO TYPE.

Because of the fact that rye is open fertile, the types and varieties are not so well distinguished as they are in wheat. In the case of wheat marked differences in the shape of the head, in the compactness of the flowers on the head, in the manner in which the kernels are covered by the chaff, in the color of the grain, and the type or length of the beards, would indicate another variety. Rye varieties are mixed in regard to most of these points and the variety depends more upon the proportion or per cent of these types to be found in the field than it does upon any one definite character. The notches on the rachis may be quite distant, causing the pairs of flowers to be scattered in the head. This usually produces a long slender head that, if fairly well filled, is quite attractive. Other heads may have such short joints on the rachis as to crowd the pairs of flowers from an upright to an inclined position. This results in a compact, wide, flat head. The original Rosen rye was mostly of the latter type.

VARIETIES.

The varieties commonly grown in Michigan ten years ago were considerably variable in regard to most of these points, but they produced small kernels, on a poorly fertilized head, usually grown on a tall slender straw. If the land was fairly fertile the straw may be expected at maturity to be taller than the average man. The color of the grain varied from yellow and orange, to brown and black. The proportion of green kernels was low.

On the other hand the Rosen rye has large kernels on a head that is generally well filled. At least 70 per cent of the heads must have less than 10 per cent of missing kernels if the field is to be passed as inspected Rosen rye. The Rosen straw is much shorter and stiffer than in the case of the common varieties. It is only the exceptional field that will produce straw as tall as the average man. The heads in a typical Rosen rye field must be nearly of the same height. Tall plants jetting up here and there (giving the surface of the field a ragged appearance) are one of the first indications that the field is mixed with common rye. The color of the grain in mature Rosen is mostly a bluish green, and should not contain dark brown or smutty colored grains.

Those originate from common rye admixture. These are the points that must be considered in inspecting the farmers' fields.

CERTIFIED ROSEN RYE.

The Michigan Crop Improvement Association began field and grain inspection work in 1917, under the leadership of the association's secretary. In the first year only five per cent of the Rosen rye acreage was considered pure enough for registration. This was due to the ordinary threshing practices and the growing of common rye in adjoining fields. The other 95 per cent was sold as commercial Rosen. It was quoted on the Detroit market that year, and carloads became available to other states.

The grain that was passed by the association's inspection became certified and was sold under the shipping tags of the association. Thus pedigreed grain became available to the farmers of other states as well as to those of Michigan. As the result of this activity in war times when farmers were being urged to sow the best seed, approximately 250,000 acres of Rosen rye were sown in Michigan in the fall of 1917.

The inspectors of the Michigan Crop Improvement Association began work in June 1918, and during the following month passed about 1000 acres. This acreage produced 22,349 bushels, a good yield when it is remembered that most of it grew on sandy soil, and that a yield of 15 bushels per acre was considered a high return before Rosen was distributed. Again under the stress of war conditions, the acreage was doubled in one year, as over 500,000 acres of Rosen and high grade Rosen were sown in Michigan in the fall of 1918. Of this about 5,800 acres were grown from pedigreed seed.

The 1919 inspection passed 468 acres yielding 10,563 bushels of pedigreed Rosen for seed in the fall of 1919. This area averaged 22.4 bushels per acre.

SPREAD TO OTHER STATES.

The growing of Rosen rye in other states began commercially as early as there was a supply. It has gone from farm to farm across the state line, into Indiana and Ohio, until the upper two rows of counties in Indiana have as much Rosen rye as the southern row of counties in Michigan. When carloads became available in 1917, the trade grew rapidly, increasing steadily since that year, and now several elevators and seed firms in Michigan count their sales of Rosen rye for seed in dozens of carloads annually. Much of this seed is purchased in sections where the rye is reasonably pure, but, unfortunately comparatively few people seem to realize that rye cross-fertilizes. A great deal of the rye that is now sold as Rosen is very badly mixed. The results obtained with this commercial seed are frequently not equal to those obtained by the use of seed inspected in the field and bin by the Michigan Crop Improvement Association which co-operates with the Michigan Agricultural Experiment Station in maintaining high standards of purity.

PEDIGREED ROSEN IN OTHER STATES.

The extension of pedigreed Rosen into other states began in 1917, when the inspection work began, but the sales made by members of the Association were imperfectly recorded that year. However in 1918 and 1919, a fair proportion of these sales have been reported. The outline map figure 3 shows the sales in 1918, and figure 4 shows the corresponding sales for 1919.

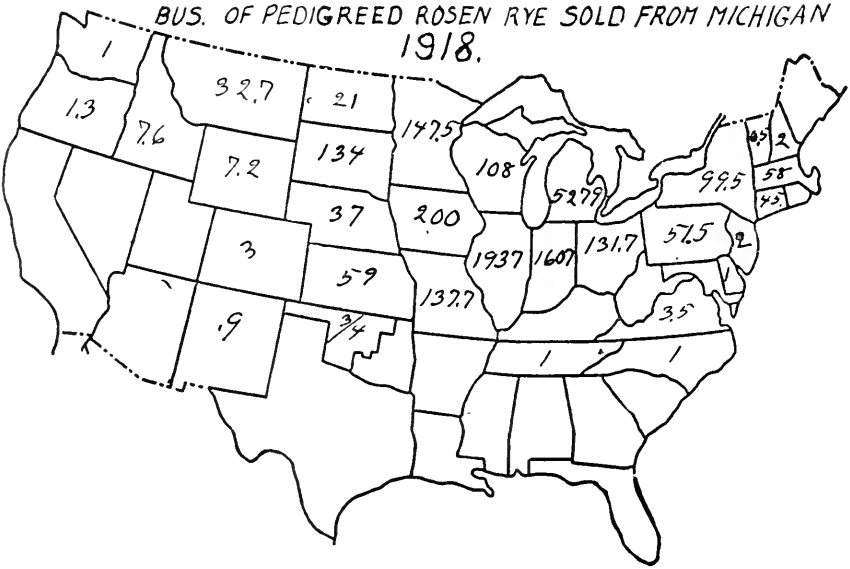


Figure No. 3. The figures on this outline map are bushels of pedigreed Rosen rye sold from Michigan in 1918 for seed purposes.

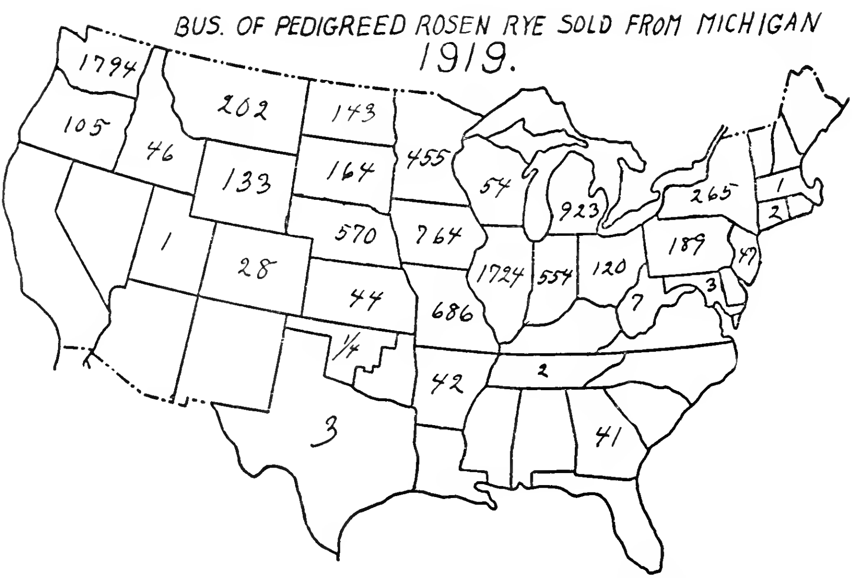


Figure No. 4. This outline map gives the number of bushels of pedigreed Rosen rye sold from Michigan in 1919.

But, as indicated above this is a very small portion of the seed sold as Rosen, as the commercial trade has assumed large proportions. The pedigreed seed, however, is the only seed of guaranteed purity, and is therefore the basis upon which this or other states must base opinion regarding the value of Rosen rye.

The figures on the two maps should be carefully studied not to be misinterpreted. In 1918 Illinois and Indiana were the largest purchasers of pedigreed Rosen rye outside of Michigan, yet it is probable that Michigan bought more pedigreed Rosen seed than all the other states combined. In 1919, Michigan farmers bought less pedigreed Rosen seed than certain other states. The State of Washington bought almost twice as much pedigreed Rosen seed as Michigan itself did. To explain these facts one must remember that pedigreed or high-grade Rosen is quite generally in the hands of Michigan farmers. They are simply planting their own seed. It is only the few who wish to replace their mixed seed with pedigreed that are now buying the pedigreed seed in Michigan.

Several states obtained the pedigreed seed in 1917 and 1918 as well as 1919 and should be growing quantities of pure Rosen rye for themselves. A report comes from Minnesota, where a man purchased the pedigreed Rosen seed from Michigan in 1918 and sold 3,000 bushels for seed in 1919. Others can do likewise. It is the more distant states, where a smaller supply is available, that are purchasing increased amounts.

At the International Grain and Hay Show given in connection with the International Stock Show at Chicago in December 1919, Rosen rye took first, second, fourth, fifth and in fact ten prizes out of the sixteen that were offered, and in 1920 it took the first 22 prizes.

THE PLACE FOR RYE.

Rye does not belong on every farm. It should be avoided by the wheat grower as it gets into the manure and requires a great deal of pulling to rid the wheat fields of it. It is particularly adapted to large areas of light sandy soil, and because of washing and leaching many of these soils should not be permitted to go through the fall and winter without growing a crop of some kind. Thus rye can be used to advantage on hundreds of Michigan farms to follow crops of corn and beans. For this purpose it should be sown as early as possible as the highest yields are obtained from September planting.

In pre-Rosen days, rye was valuable mainly as a catch crop, and to sow on lands that were not suited to wheat. Few people thought of putting rye in as a regular crop, especially on the heavier soils. Rosen rye can be considered a regular crop, to be studied and treated as such. In the region around Parma in western Jackson county, Rosen rye has crowded out wheat, as the farmers of that section say that it is more profitable than wheat as a general crop. Each farmer needs to settle this matter for himself, but he should not grow wheat and rye on the same farm.

It should not be forgotten that profitable rye crops come from (1) the use of fertilizers such as manure, acid phosphate; (2) a thoroughly prepared seed bed; (3) September or early October planting; (4) and the planting of pedigreed or high grade Rosen seed. The crop should be planted under the most favorable conditions, unless prevented by conditions beyond control.

The best rate of seeding Rosen rye depends somewhat upon conditions. In the Parma district, farmers recommend the use of three pecks per acre of well cleaned seed, sown early, on a well prepared fertile seed bed. Those who do not have as good conditions must sow more. At the College the

rate of seeding tests indicate that a bushel of seed per acre is the most profitable rate of good seed to sow.

The time of seeding tests at the College indicate that September 20th to October 10th is the best time to plant. The results are as follows: a plat that would yield at the estimated rate of 46 bushels per acre if planted

Figure No. 5. A portion of a date of seeding test. The tall strips near the center and to the right of the picture were planted October 10th. Between these two, are three strips, one planted November 21, 1918, and the other two in April, 1919. The spring plantings never headed out.

September 25th, would yield 45 bushels if planted September 30th; 39 bushels if planted October 15th; 20 bushels if planted October 25th; 10 bushels if planted November 5th; 4 bushels if planted November 20th. Four spring plantings were made from Rosen rye. None of them headed out. This experiment shows that greatest success depends upon planting sufficiently early in the fall.

DISTRIBUTION OF CERTIFIED ROSEN RYE BY THE MICHIGAN CROP IMPROVEMENT ASSOCIATION.*

The rapid increase in acreage of Rosen rye in Michigan has been due not only to the superior yielding qualities of this rye but to the fact that ample supplies of high grade seed, unmixed with common rye have been annually available from the Michigan Crop Improvement Association growers.

The Michigan Crop Improvement Association is an organization of Michigan farmers particularly interested in increasing crop production through the use of superior varieties, best methods of cultivation and fertilization. This association may be joined by any farmer or seed grower of Michigan interested in crop improvement.

Through the association, large increases of desirable varieties kept pure by careful inspection, are obtained in a relatively short time. Improved

*By J. F. Cox, Head of the Farm Crops Section.

varieties, would in many instances rapidly become mixed with inferior strains were it not for the careful field, and threshed grain inspection system, which the association maintains. The rapid spread of Rosen rye, Red Rock wheat, Robust beans and other varieties, has been made possible largely through the Michigan Crop Improvement Association.

Close co-operation exists between the Crop Improvement Association and the Farm Crops Department of the Michigan Agricultural Experiment Station. Improved strains, developed at the Experiment Station, are made available to members of the association for rapid increase under field conditions. The secretary of the association keeps a careful record of the origin and transfer of strains of improved crops. The association maintains a system of field and threshed grain inspection for members who are interested in commercial production of high quality grain for seed. Seed which passes the certification rules of the Board of Directors of the Association must be of very high standard and successfully passed upon in the field by inspectors, working under the direction of the Farm Crops Department, and must again pass careful inspection after threshing. The cost of certification is borne by the Crop Improvement Association.

Arrangements have lately been made which insure the co-operation of the newly created Michigan State Farm Bureau Seed Department in the distribution of seed guaranteed by the Crop Improvement Association.

IMPROVEMENT BY HEAD SELECTION IN THE FIELD.

Several of the most careful Rosen rye growers have been following the practice of selecting enough of the best heads in the field to plant a seed plat of one-half an acre or more in size. This seed plat is carefully isolated and, after further head selections for another year's planting are made, it is har-

Figure No. 6. A Jackson County Farmer's Increase Plat of "Head Selected" Rosen Rye.

vested separately and the seed used to plant a general field the following year. In 1921 three growers in lower Michigan have approximately 40 acres of such head selection stock for distribution. It is markedly superior to ordinary certified rye.

All members of the Michigan Crop Improvement Association, who plant rye in the fall of 1921, will be required to secure their seed from head selected stock grown by these growers. All certified Rosen sold in 1922 will therefore be only two generations removed from carefully selected Rosen.

MANITOU ISLAND ROSEN.

The entire acreage planted to rye on the South Manitou Island is now planted to certified Rosen. The South Manitou is an island of approximately 7,000 acres, located 10 miles off shore directly west of the Leelanau Peninsula. From 70 to 120 acres of rye is grown annually on the island. For the past two years head selection work has been carried on by the Michigan Agricultural Experiment Station.

During the coming fall the entire acreage of the island will be planted from seed two seasons removed from careful head selection. This year's head selected plat will be increased on a 10-acre field and next year all who grow rye on the island will get their seed from this increase. This course will be followed for a number of years.

Owing to the isolated position of the island it is easily possible to prevent common or other varieties of rye from being grown.

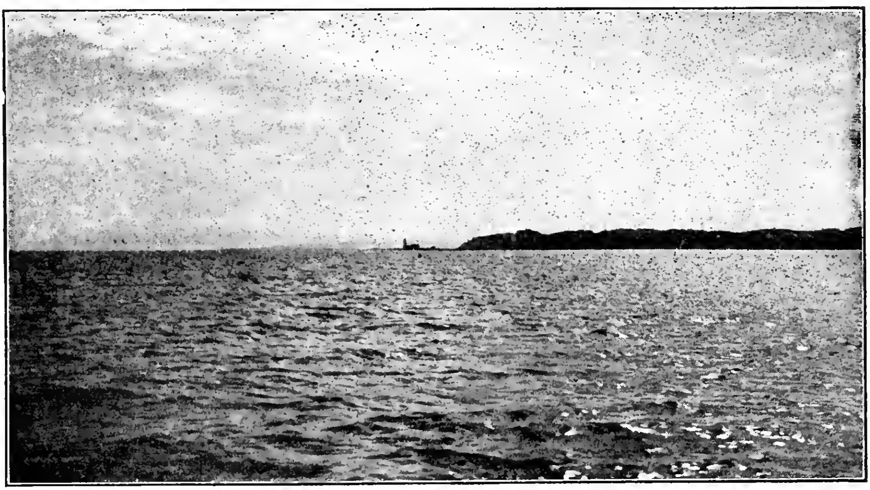


Figure No. 7. The South Manitou Island off the shore of the Leelanau Peninsula. The entire rye acreage of this Island is now planted to selected Rosen rye, and will serve as a source of high-grade seed, produced under isolated conditions.

Growers on the island have formed an island Chapter of the Michigan Crop Improvement Association. By careful head selection and field inspection it is expected that the South Manitou Island will furnish a source of exceptionally pure, high yielding rye.

The first prize offered for rye at the 1920 International Grain and Hay Show was won by a South Manitou Island rye grower.

POISONING FROM BACILLUS BOTULINUS

Cause: Prevention; Treatment

Circular Bulletin No. 47

BY ZAE NORTHRUP WYANT,* BACTERIOLOGY SECTION

Early History—Food poisoning from *Bacillus botulinus* has been known for a goodly number of years to be more or less prevalent both among human and animal kind. Allantiasis, or botulism—the name by which this type of poisoning is most commonly known—has been recognized by German physicians since the latter part of the 18th century, the first recorded case occurring in 1735. A serious outbreak occurred in Germany in 1793 from eating sausage which contained a great deal of blood. After this time the number of cases of botulism, so-called because the disease was produced from eating spoiled sausages, rapidly increased. Many sections of Germany were involved, official warnings failing to check their incidence. Several outbreaks of this ''sausage—or meat—poisoning'' were reported from Russia, Austria, Hungary, Denmark, and France, and one each from England and Holland.

Botulism in America—In America comparatively few cases of botulism have been recognized but a survey of the reports of food poisoning during the past 25 years shows that there have been a number of cases, mostly in California, in which the symptoms are more or less indicative of this condition. It is probable that many cases of so-called ''ptomain poisoning'', in the past thought to be the common type of food poisoning, have actually been botulism.

Botulism in Horses.—Among livestock botulism has probably been known for many years. In 1813 a fatal disease of horses termed ''head disease'' appeared in Germany. This affection spread through certain sections of Europe from 1824 to 1828 and was described as ''fever of the nerves''; later as ''nervous sickness'', and ''Borna disease'' from the fact that it was prevalent around Borna (Germany). In the United States various names such as ''cramp of the neck'', ''mad staggers'', ''sleepy staggers'', ''blind staggers'', or simply ''staggers'', ''cerebritis'', ''cerebrospinal meningitis'', ''forage poisoning'' and the like have been used to designate this disease in horses and mules. In some sections of the United States it is also called ''pasture disease''.

In Cattle.—Among cattle such other names have been applied to this disease as ''corn stalk disease'' and ''silage poisoning.''

*Resigned June 30, 1921. Correspondence relating to this subject should be addressed to Bacteriological Section, East Lansing, Michigan.

In Chickens.—"Limber neck" is the term applied to this disease in chickens.

CAUSE.

Ptomains and Toxins Contrasted.—Botulism is essentially a food poisoning produced by a toxin, in contradistinction to ptomain poisoning. *Ptomains*, comparatively few of which are poisonous, are a part of the molecule of a protein food which has been attacked and broken down by microorganisms, or in the chemical laboratory. Toxins, on the other hand, come from the microbial cell itself. They cannot be produced in the chemical laboratory. They are a product of the living cell only.

Toxin Absorbed from Alimentary Tract.—Botulism is caused by the presence in and absorption from the alimentary tract (of both humans and animals) of toxin produced by *Bacillus botulinus*, a large anaerobic, spore-forming bacillus.

Toxin Produced in Food.—"How does the toxin of *B. botulinus* get into the alimentary tract?" is a question arising next. When this bacillus grows in suitable food under suitable environmental conditions such as proper temperature and lack of air, this toxin is produced. Whether food poisoning is produced or not depends upon whether this particular food is eaten, and the severity or fatality of the poisoning depends upon the amount or virulence of the toxin present. The toxin of *B. botulinus* is unique in that it is so far as is known, the only true toxin which is absorbed through the intestinal walls. This is an important factor in the causation of intoxication from this source. Toxins of the tetanus and diphtheria bacillus, on the other hand, have beer shown seldom to survive the biochemical activities in the digestive tract.

Temperature Favorable for Toxin Production.—Another difference between the well known toxins just mentioned and that of *B. botulinus* is, that under conditions where the former toxins are ordinarily dangerous to health they are produced by their respective organisms inside the animal body, at body temperature (about 37.°C.). The *B. botulinus* toxin, to the contrary, is produced perhaps most frequently, *outside* the animal body at temperatures considerably *below* body temperature, e. g., 20-22°C.

Food Stuffs Favorable for Toxin Production.—Another, and perhaps a more important factor in the causation of botulism is that *B. botulinus* appears to be able to grow and produce its toxin in a wide variety of food stuffs, both animal and human, not only under anaerobic but under apparently aerobic conditions. Upon consulting many late text books, it will be noted that the findings of van Ermengem who discovered *B. botulinus* in 1893 are taken apparently as the last word on the subject. Modern researches have shown that in this as well as in similar cases, this "habit" which many authors have of repeating the statements of previous writers without experimental proof of their correctness, is reprehensible. It has been found, for instance, that the germ producing this particular type of food poisoning can grow not only in sausage, and other meat products, but in canned vegetables and even in canned fruits; that the acid of certain vegetables and fruits is apparently not as inhibitive to the growth of *B. botulinus* as has been stated heretofore; and that not uncommonly, it seems to grow in silage in the apparently aerobic portions of the silo, most probably in association with molds and other microorganisms found in the silage.

PREVENTION.

Effect of Heat on *B. botulinus* Spores.—A very false sense of security is given by various text books due to the fact that van Ermengen's statements with regard to the low thermal death point of the spores of *B. botulinus* have been copied without proper qualifications. These statements are to the effect that the spores of *B. botulinus* are easily killed by heating at 80°C. (176°F.) for 60 minutes.

Ordinary Canning Methods Not Effective.—If these statements were true of all strains of this organism, the amount of heat applied in any one of the four well recognized methods of canning would be sufficient to destroy the spores: (1) hot pack or open kettle; (2) cold pack, hot water bath or steam; (3) intermittent sterilization; (4) pressure canning. *Experiments by various investigators in different parts of the United States, however, show that the spores of most all strains will resist much higher temperatures than 80°C. for a considerable length of time.* Burke of California (1918) found that spores of certain strains of *B. botulinus* would withstand 100°C. (212°F.) for 3½ hours, and in the foam which gathers on the side of the kettle they may live for a much longer period. One period of heating in boiling water for five hours or less will not sterilize the contents of jars if they are contaminated with the more resistant spores of this bacillus. She found that because of the much delayed germination of spores due to heat injury, fractional or intermittent sterilization on three successive days is of doubtful value since the spores *do not develop before* the third heating period. Even pressure canning cannot be considered safe if a pressure of 5, 10 or 15 pounds is applied for only 10 minutes. A comparatively long sterilization period must be used.

Effect of Protein, Acid and Sugar on Spores.—Experiments were also performed at the University of California (1919) which showed (1) that the spores of *B. botulinus* when mixed with animal or vegetable protein are much more resistant to heat than has been believed. (2) When lemon juice (5 to 7 oz. per gallon of vegetable) is added, the thermal death point (killing temperature) is markedly lowered when heat is applied. (3) Cane sugar in concentrations up to 64 per cent does not prevent the growth or toxin production of *B. botulinus* although both are inhibited to a certain extent, and (4) in connection with this, the particular fruits tested which had been canned in sugar syrup were suitable as a food for this organism. (5) Certain technic of the canning method of commercial as well as of home canners may be inefficient if the raw material happens to be contaminated with the spores of *B. botulinus*, for example, the degree of heat used in processing may not be applied sufficiently long to reach the center of the cans at all, or for an effective period.

Why We Fail to Prevent Botulism.—It is very evident that it would be quite impractical to think of preserving poultry or stock-foods in the manner used for human foods. The solution of prevention of botulism in both types of food then apparently lies in preventing the original contamination. Our knowledge, however, of the habitat of *B. botulinus* in nature is so limited that the preventive measures we take are not sufficiently exhaustive. If *B. botulinus* could be wholly prevented from gaining entrance to or developing upon food, botulism would not occur. Thus it is seen that lack of wide human knowledge, combined with human failings where knowledge is present, are responsible for many of the outbreaks of botulism.

Habitat of *B. botulinus*.—A brief review of the various places where *B. botulinus* has been found should be of interest in this connection. Burke of California has done considerable work in attempting to locate in what types of material this bacillus may be found. She concludes that this organism is widely distributed in nature; that it seems to occur in the vicinity of the habitations of man; that it may be present in the garden and thus be on the fruits or vegetables when picked, whether they are decayed or sound; that spiders or small insects may aid in distributing this organism in the garden; that it may be harbored in the intestinal tract of an animal for at least four months after contaminated food is eaten. Van Ermengen (1895) never succeeded in finding the bacillus in anything except two speciments of ham which had caused poisoning in humans, although he searched for it in various kinds of soils and manures, mud from ponds and rivers, and the like. Kempner and Pollack (1897) found *B. botulinus* in the intestinal contents of a "normal" hog. This was the only recorded case of the isolation of *B. botulinus* from nature until Burke's findings.

Boiling Food Destroys Toxin but Not Spores.—Along with preventive measures one which has been given most publicity within the last two years is that boiling any food suspected of containing the toxin of *B. botulinus* destroys the toxin if present and thus entirely prevents the likelihood of botulism ever occurring from the eating of this particular food. A very recent publication from the Bureau of Chemistry, however, indicates very strongly that, if *B. botulinus* is present in any food, the short heating given it to destroy the toxin is *not* sufficient to kill the spores, and if a large enough number of the spores of this bacillus is present in the food, botulism may result just the same, the symptoms only being delayed, due to the time it would take for the spores to germinate and for a sufficient number of bacterial cells and consequently toxin to form. This was proved to be the case with experimental animals. Botulinus toxin is now known to be produced at body temperature as well as at lower temperature, contrary to the belief of a few years ago.

Don't Heat and Eat Spoiled Food, Destroy It.—As the above statement from the Bureau of Chemistry seems to have adequate experimental proof it seems very unwise to continue to recommend that food which seems a little "off" may be safely eaten when heated. Rather it seems best to advocate the destruction of such food by burning, and not merely getting rid of it by feeding it to chickens or pigs, or even by burying it.

The Question of Odor.—A word may not be amiss here with regard to whether or not there may be an offensive odor present in food containing *B. botulinus*. Sufficient observations and experiments have been made to enable the statement to be made that not in all cases has the food (human or stock) had an offensive odor when this germ and its toxin were found to be present. In fact, authorities disagree at present as to whether the germ of botulism ever causes the production of a disagreeable odor in foods. The fact remains, however, that many of the foods which have proved to be toxic and to contain this bacillus have had a more or less definitely offensive odor.

Train the Eye to Detect Spoilage.—The nose alone should not be relied on to detect spoilage. The eye can detect spoilage in canned goods. For instance, a tin can may have one or both heads swelled; a glass can may have a bulged lid, or may show signs of leakage, of gas bubbles in the can, of a light colored sediment, of disintegration of the food product, and upon

opening, absence of vacuum, or spurting liquid showing gas pressure. These signs of spoilage may be indicative of the presence of *B. botulinus*.

Never Taste Questionable Food.—If the eye or nose condemns the food, the sense of taste should *never* be used. Many of the fatal cases of botulism were of persons who just tasted the food to see if it was all right.

TREATMENT

Two Distinct Types of Botulinus Toxin.—So far nothing has been said to indicate whether all strains of *B. botulinus* are alike. The workers at the University of California may be given the credit for discovering that there are at least two distinct strains of this bacillus depending on the type of toxin produced. They have designated these strains as *B. botulinus*, Type A, and *B. botulinus* Type B.

Why Botulinus Antitoxin Has Failed.—It is a well known fact that when a certain amount of diphtheria antitoxin is injected into an animal it protects the animal against a definite dose of diphtheria toxin; the same is also true in the case of tetanus toxin and antitoxin. It is not possible, however, to protect an animal against tetanus toxin by injecting any amount, however large, of diphtheria antitoxin. The toxin produced by the type A botulinus bacillus is not the same as that of the type B organism, and further, the antitoxin of type A bacillus will not protect against the toxin of the type B bacillus or vice versa. This peculiar fact has been proved experimentally and explains many of the failures when attempts have been made to prevent or alleviate the intoxication in humans poisoned by the toxin of this bacillus; the wrong type of antitoxin was used.

The Value of Polyvalent Antitoxin.—Hence if anyone is suffering from suspected botulism, sufficient of a mixture of the two types of antitoxin, or as it is termed a ''polyvalent'' botulinus antoxin, should be given in order to be certain of neutralizing, or counteracting the effect of whichever toxin is present.

No Cure for Botulism, Symptoms Occur Too Late.—So far as is known, no medicine is of any value in the treatment of this disease. As the symptoms are a result of the action of the toxin on certain portions of the nervous system it is very evident that some time must have elapsed before symptoms appeared and no medicine could then be of avail, if administered by way of the mouth, or even if injected. When symptoms begin to show it is generally too late to do more than give a therapeutic dose of a specific or of a polyvalent botulinus antitoxin.

Preventive Measures in Canning.—The prevention of botulism in human foods then rests upon the housewife or the commercial canners; first, upon the cleanliness in the preparation of the food from garden to can; second, upon employing sufficient heat in processing to destroy the spores of the most resistant bacteria which may be present; third, taking particular pains to seal each can immediately after sterilization and store in as cool a place as possible.

In Preparing Meals.—The one who prepares the meals must be looking out to prevent botulism by a careful appraisal of all canned goods before and after opening, with the sense of sight and smell only, *not* with the sense of taste, especially if anything seems wrong with the can contents. These precautions should not be limited to canned goods, however, since it will

be remembered that sausage and other forms of meat not canned have also at times been contaminated with *B. botulinus*.

Moldy Silage Suspicious.—In the case of live stock, the one who has charge of feeding them, with silage especially, should look with suspicion upon moldy portions. Neither molds not their products have been proved to be poisonous, but, because of the possibility of the presence and growth of *B. botulinus* under such conditions, spoiled silage should be fed with great caution. However, other feeds, such as hay and grain, which have been found to be contaminated at times, appeared perfectly normal.

Necessity of Further Experimentation.—Thus it is very evident that more exhaustive experiments should be performed in the preparation of human foods in order to revise the time and temperature tables for processing canned goods of all sorts, in all kinds and sizes of containers, and in the handling and preparation of stock foods, so that the possibility of spoilage from organisms of the botulinus type may be reduced to a minimum.

Modern Canning Factory Methods Safe.—The modern canning factory in Michigan as well as in other states is, at the present time, putting up the various food products in a sanitary, safe and economic manner and in addition, maintains a rigid inspection service which serves to eliminate practically all spoilage among canned foods on the market. This means then that the house wife need not hesitate in buying foods canned in any up-to-date factory. The canner has at stake not only his reputation but his profits and thus for a selfish reason if no other, he is obliged to eliminate to the best of his ability losses from all sources.

INDEX.

INDEX.

A.

B.

C.

D.

E.

F.

G.

H.

I.

L.

M.

P.

R.

S.